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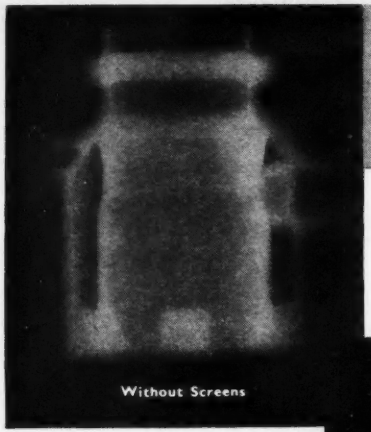

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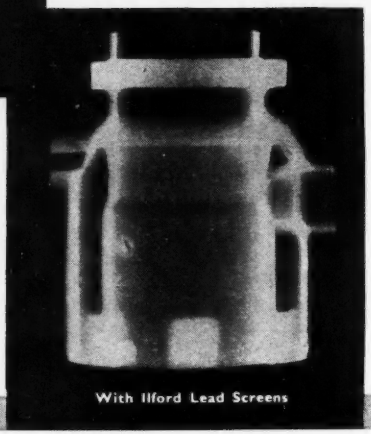

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DISCOVERY

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The Progress of Science

A MONTHLY NOTEBOOK COMPILED UNDER THE DIRECTION OF DAVID S. EVANS

Artificial Insemination

THE general public is now well aware of the value of artificial insemination in improving livestock. It also appears that on a small scale it has been used with human patients both in this country and abroad. Naturally enough the practice is not widespread, nor is it ever likely to be used except in cases where there is a history of injury or some other defect in either partner which prevents conception in the normal way. Clearly, too, there are some knotty social and legal problems ahead which, under our present legal system, are not likely to be solved except through the process, which may be far from satisfactory in such highly specialised and delicate matters, of their being made the subject of a test case, the result of which will constitute a legal precedent. At present, according to the Minister of Health to register as legitimate a birth which occurs as a result of artificial insemination is a breach of the law.

In a general consideration of the advantages and disadvantages of the method the strongest recommendation for its use will be found in those cases where a husband has, through injuries suffered in the service of his fellow men, lost the power to reproduce children in the normal way. The desire, not only of himself but of his wife, for children will be frustrated and a heavy additional burden imposed on both partners. Here the method of artificial insemination will provide an impersonal way out; if this method is not adopted the strain of this unnatural situation is liable to drive the parties to seek the co-operation—the word is used deliberately, and not as a euphemism for illicit relations—of other parties, as happened in one peculiarly distressing and painful case recently reported in the Press. No one pretends that the use of artificial insemination as applied to human beings is an attractive idea, but it may well provide a small number of human beings, afflicted through no fault of their own, with a way out of their difficulties, a way which will not bring in its train other factors likely to destroy a happy marriage.

The remarks of the Archbishop of Westminster made recently to a gathering of Catholic doctors therefore seem peculiarly out of place and premature. The ban of the Catholic Church on the artificial restriction of families is now paralleled by a ban on their artificial extension, a ban which presumably would extend to cases (that may perhaps arise) when the impregnation of a wife even by her own husband is possible only with artificial aid. The logical basis of this attitude is difficult to comprehend. If it is that, whatever the circumstances, nature must be allowed to take its course, then the mere existence of medical men should be held to be sinful. It is not desired to labour this point; the implications will be obvious enough. The intention is merely to deplore the choice which this representative of the Catholic Church has made in giving guidance to the medical members of his sect. An even greater degree of disapproval is aroused by his stigmatisation of a State Medical Service as a project not to be supported by Catholic doctors on the sole ground that they might, as members of it, find themselves drawn into courses of action repugnant to the Church. Even if one can bring oneself to a momentary understanding of this repugnance, the logic of the situation still escapes one. The case would seem to be on all fours with a refusal to build a bridge across a river on the ground that it might eventually collapse and kill some people who happened to be on it at the time. The attitude is one which seems to merit the application of the word jesuitical, using that word with all its connotations of the hair-splitting justification of preconceived courses of action which it has, rightly or wrongly, acquired.

Telepathy: A Scientific Attitude

A CORRESPONDENT recently wrote suggesting that our selection of subjects was rather too severely orthodox, and asking us to include items dealing with such subjects as telepathy, faith healing, water divining, spiritualism and so on. There is almost certain to be at least one champion of each of these subjects who will protest at our mention of topic X along with what he regards as scientific riff-raff or worse, and there will be many scientists who will lump the whole lot together under this heading. A good many of these topics have fallen into the riff-raff category solely as the result of the advocacy of their champions,

a good working definition of scientific riff-raff being any subject on which one is liable to receive a letter on the following lines: *How can you be so blind as not to see this great truth. There is a conspiracy of scientists against me. This knowledge has been handed down from the ancients, and there are more things in our philosophy, etc., etc.* In other words a topic goes into the riff-raff class if its exponents rail against the normal and extremely stringent examination which is made of every new theory advanced in science. Naturally the examination is the more stringent the more world-shaking the consequences of any theory are likely to be, and it is approached with a greater degree of caution and mental reserve when its acceptance would demand a radical revision of concepts which have stood the test of time and have long been in use as the ordinary tools of thought. This, for example, explains the marked lack of enthusiasm which has been accorded to, say, J. W. Dunne's ideas about time, which are not only obscure, but which—if correct—would also seem to upset the whole basis of physics without leading to any useful result. Nor do they satisfy a second essential criterion—that they provide a possibility of experimental verification which would enable an investigator to discriminate between one variant of the theory and another. The general attitude of the scientist in this particular case is that he may admit the observational facts to a degree depending on his opinion of Mr. Dunne's capacity for experimental investigation but few, if any, will follow Mr. Dunne's line of deduction from these alleged facts.

Here we have yet a further criterion: the opinion which may be held of the technical capacity of the investigator. To take an extreme case, quite unrelated to any person or persons living or dead, it might happen that a quite startling and apparently attractive theory has been advanced by a man who in addition has proved to his own satisfaction that he is Napoleon Bonaparte. Such a conclusion tends to destroy his credibility, and it is quite legitimate for us in every case, especially when the investigator is personally unknown to us, to attempt to form some estimate of his credibility as a witness.

Recently a book by Mr. Whately Carington entitled *Telepathy* came into our possession which does much to lift this topic out of the riff-raff class, not because his book compels agreement on all points (indeed Mr. Carington expects disagreement on many of his conclusions) but because, for a variety of reasons presently to be explained, it looks as if he may eventually get somewhere as the result of his work. We ought perhaps to begin by apologising to Mr. Carington, who is personally unknown to us, for making him the subject of a homily on how to assess the value of the discussion of a subject whose past history is such as to fill us with suspicion. However, the character of his book gives us a certain confidence that he is a scientist who will perhaps even welcome such a discussion. In the first place he does not claim too much, nor rail at "scientific orthodoxy" for its lack of sympathy, while his discussion of the mental resistances exhibited by some scientists appears quite justified. Consultation of his list of references shows that he has been in association with men of standing whose names have a reputation for integrity, and that he has never had to publish his work at his own expense.

The next point at which Mr. Carington scores marks is that he has a theory which can be tested by reference to experiments, and from which consequences, verifiable or disprovable, can be deduced; in addition Mr. Carington is willing to test the theory himself and allow other people to do so. Briefly his theory is that if one person has in his mind an idea K, and in addition an idea O, then a second person also having the idea K is more likely to have the idea O in addition than if the idea K were absent from his mind. The word "idea" connotes any aspect of, for example, some unusual object or some common past experience and the K-idea, as he calls it, then forms an associative link between the two subjects to which other ideas can "stick". If this is so, then there would be, of course, for any one person a multitude of K-ideas linking him to all sorts of other people, and the occurrence of a telepathic phenomenon would be the outcome of a competition between all these various K-ideas. The experimental technique has to be designed with some subtlety, since, for example, Mr. Carington considers that he found evidence of the idea of "taking part in an experiment" acting as a K-idea.

Now it is not our business to say whether or not we accept Mr. Carington's evidence for the occurrence of telepathy. Most of us, at one time or another, have had experiences which would at any rate be consistent with this idea, and seem rather difficult to explain by other means. However, such isolated instances have little evidential value, and the type of laborious statistical analysis undertaken by Mr. Carington is the only satisfactory way, provided, of course, that such a procedure does not in some way exclude the possibility of the phenomenon from the start because of the mental conditions under which it is conducted. In any case, the amount of evidence advanced in his book is admitted to be insufficient to form a judgment and reference must be made to various investigations which have been described.

Nor does the fact that Mr. Carington's theory, if true, is insufficient to answer all the questions we should like to ask diminish the value of his contribution. If his statement about an increased frequency of occurrence of certain ideas is proved experimentally, that is all that we can ask at this stage. It is after all, no uncommon thing for a new theory to raise more questions than it solves. At the end of his book, Mr. Carington goes on to discuss certain possible consequences of his work, and there, as he admits himself, he will not carry many of his readers with him: he certainly did not carry the present writer. But taking all things together this is a refreshing book. If, in perhaps another century or so, some of these problems are beginning to yield to the attack of scientific method, the credit will be due to such men as Mr. Carington who are making an attempt at clearing away the mumbo-jumbo and replacing it by serious research.

Bacteria Supplement our Vitamins

For a number of years evidence has been accumulating which makes necessary a considerable revision of our outlook on the relation between vitamins and diet. In assaying human requirements of the various known vitamins it had long been assumed that all the vitamins the body obtains come to it from outside sources. On this assumption analysis of the vitamin-content of the daily

diet would provide a complete estimate of the quantity of vitamins the body is obtaining. Recent research has shown that this belief is incorrect, for all animals, including man, have internal sources of supply whose contribution cannot be ignored. Responsible for this unsuspected source of supply are the micro-organisms, mainly bacteria, which swarm in the intestines of all animals. Many of them possess the ability of synthesising vitamins.

Up to the present the most complete studies have been made with vitamins of the B group. The results obtained indicate that the intestinal bacteria can, under favourable conditions, synthesise sufficient quantities of the B vitamins to maintain health even when the diet, over a period of many months, contains negligible amounts of B vitamins.

This important role of the intestinal bacteria was first discovered in animals. The first experiments on man were made by two American workers in 1943. Nine human volunteers were kept on a synthetic diet containing negligible quantities of vitamin B_1—known in America as thiamin, in Britain aneurin—but adequate amounts of all other known vitamins. After a month on this diet four of the volunteers showed marked symptoms of beri-beri, the disease caused by vitamin B_1 deficiency, and one showed slight symptoms. The remaining four, however, remained perfectly healthy and, in spite of the absence of the vitamin in their diet, continued to excrete vitamin B_1. The four who developed beri-beri excreted no vitamin. If significant amounts of the vitamin are being excreted weeks after it has been eliminated from the diet it is reasonable to postulate that synthesis must be going on.

Support for this idea was obtained through the use of the drug known as succinyl sulphathiazole. Although this drug is normally used to control harmful intestinal bacteria, such as those which cause a form of dysentery, it also destroys many of the harmless bacteria. Hence one would expect this drug to reduce considerably the internal production of vitamins. This has in fact been observed. When one of the volunteers who continued to excrete vitamin B_1 was given sulphathiazole excretion of the vitamin ceased within a week.

Subsequent experiments on similar lines have shown that nicotinamide (the anti-pellagra vitamin) and riboflavin —both of these are members of the collection of vitamins called vitamin B_2—can be produced in the intestines in the same way. Experiments on rats have demonstrated the production of a number of other vitamins, notably biotin (formerly called vitamin H), pantothenic acid, vitamin E and vitamin K.

These discoveries lead to a number of important conclusions. Many puzzling anomalies can be explained such as the fact that people sometimes fail to develop symptoms of vitamin deficiency even when the particular vitamin is for a long time low or lacking in the diet. A possible explanation is given of the fact that milk has a curative effect on pellagra although it contains but negligible amounts of the anti-pellagra vitamin; it is suggested that a milk diet promotes the activity of bacteria able to synthesise this vitamin.

It is now necessary to revise our views on man's vitamin requirements, at any rate with regard to the B group, and critically review the evidence on which past estimates have been made. These estimates took no account of an internal vitamin source, a fact which probably goes far to explain the very varying results obtained by different investigators. Although research with human subjects is still very limited it appears that, with vitamin B_1 at any rate, the intestinal bacteria can produce up to 100% of the vitamin required by a human being. The number and variety of bacteria present in the intestines depends on many factors such as diet, age and personal habits. It would be extremely difficult to estimate the capacity of any individual to synthesise his own vitamins without long and elaborate experiments and even if an estimate was obtained it might be valid for only a short time. Daily vitamin requirements must be recalculated on the assumption that no internal synthesis occurs, since, almost without exception, a vitamin intake considerably in excess of requirements is not harmful whereas even moderate deficiency results in ill-health.

Many different functions have been attributed to the intestinal bacteria but their great importance is only just beginning to be realised. Nutrition experts and bacteriologists must investigate the general effect of different diets on these bacteria with particular reference to their vitamin-synthesising capacity. The conclusions here discussed represent the integration of research going back many years. Much remains to be done but the final crystallisation of ideas which has followed the much more intensive research of the past few years must be regarded as an event of outstanding importance in the study of the vitamins.

Mass Production's Grandfather

THE system of mass production is associated, in the minds of many workers, with its use as a method for worsening their conditions of labour. However, as is the case with so many other scientific advances, the use is determined by its controllers, and is not inherent in the system. In the U.S.S.R. the mass production system finds its true value as a means, in peace-time, for reducing labour and for increasing output in the general interest, and in war-time is a form of co-operative effort, whose value is understood by those who operate it, serving to hasten victory.

But though we tend to think of the modern mass production system in terms of Bedaux or Stakhanov according to our lights, it is of interest to consider the history of the system itself as an example of the application of scientific method to manufacture. In the issue for November 1944 of the *Journal of the Franklin Institute*, Dr. Thomas Coulson has described some early episodes in the history of mass production, especially in relation to the development of interchangeable parts for small arms.

It appears that the idea was tried on two occasions in the 18th century in France, the second occasion being recorded by a letter dated August 30, 1785, written by Thomas Jefferson, then Minister to France. Jefferson described the work of a mechanic named le Blanc who had introduced interchangeable parts into the manufacture of small arms, and told how he had assembled one weapon from parts chosen at random.

Priority for the system in the United States is disputed as between Simeon North, first official pistol maker to the U.S. Government, and Eli Whitney, another arms manufacturer. It is worth noting that the manufacture of arms and of clocks were the only two industries in which the idea of interchangeable parts was applied before the

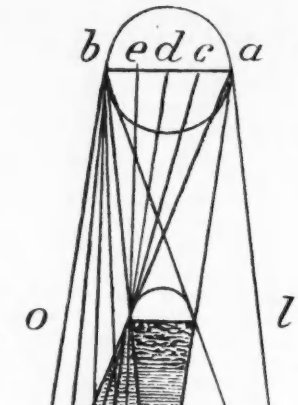


FIG. 1

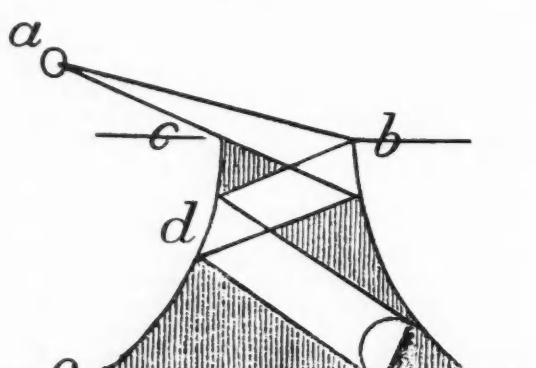


FIG. 2

general introduction of the mass production system. In the case of the arms industry the difficulties had become acute, and, for example, in 1812 the British Government had no less than 200,000 muskets requiring small repairs, of a kind which to-day would be done by replacing one or more standard parts, while the men of George Washington's army had to carry individual moulds for their bullets because their muskets varied so much in calibre.

Surprisingly enough the high degree of skill needed in the two industries mentioned did not diffuse to others; for example, at a time when clockwork of the most intricate and accurate kind could be manufactured, James Watt could not find a mechanic who could bore a cylinder sufficiently uniformly to be steam tight.

To return to North and Whitney: both found that the tooling-up process was extremely expensive and that most of the cost had to be laid out before even a single weapon was completed—an early example of the modern phenomenon of increasing capital costs as compared with the profits earned. North, for example, wrote in 1808, discussing the contract for pistol manufacture which had been awarded to him:

"To make my contract for pistols advantageous to the United States and to myself, I must go to a great proportion of the expense before I deliver any pistols. I find that by confining a workman to one particular limb of the pistol until he has made 2000 I save at least one quarter of his labour to what I should provided I finished them by small quantities, and the work will be as much better as it is quicker made.

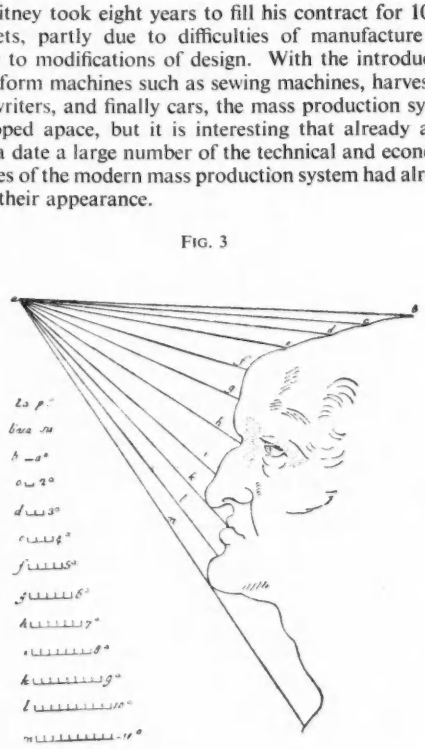
"To proceed in this way I must purchase the most of my stock and bestow a great proportion of the labour upon it before I can finish a pistol . . . I have seventeen thousand screws and other parts of the pistols now forged and many parts nearly finished and the business is going on pretty lively".

Whitney seems to have had the same idea independently, for in 1800 Captain Decius Wadsworth wrote:

"Where the different parts of the lock are each formed and fashioned successively by a proper machine and by the same hand they will be found to differ so insensibly that the similar parts of different locks may be mutually substituted. The extending of this principle to all parts of the musket has been a favourite idea with Mr. Whitney from the beginning".

Whitney took eight years to fill his contract for 10,000 muskets, partly due to difficulties of manufacture and partly to modifications of design. With the introduction of uniform machines such as sewing machines, harvesters, type-writers, and finally cars, the mass production system developed apace, but it is interesting that already at so early a date a large number of the technical and economic features of the modern mass production system had already made their appearance.

FIG. 3



Leonardo da Vinci on Light and Shade

LEONARDO, recommending himself to a patron, gave a list of his accomplishments ending with the remark that "in painting, I can do as well as anyone else". This was indeed true, and he stands as a painter of the very first rank judged by comparison with any artist in history. He also has a reputation as a scientist, based for example on his conception of a flying machine, but many people do not rank him very high on this score: after all the wish to fly has been generally felt almost from time immemorial and it does not require much originality to design on paper some sort of bird-like contraption. An interesting side-light on the scientific quality of Leonardo and in particular on his application of scientific method to painting and perspective is provided by his *Trattato della pittura*, part of which, under the title *Traité du Paysage*, was published in French translation by Librairie Delagrave of Paris in 1940. Much of this is essentially scientific and deductive in character and exhibits a very remarkable insight, although there are, intertwined with the almost modern scientific notions, a considerable number of semi-magical and imitative ideas. The latter are most apparent in the part of the book dealing with "aerial perspective", by which he understands not the apparent convergence of parallel lines which we to-day associate with the idea of perspective but the differences in appearance of objects seen through the air under various conditions of illumination. He has the idea for example that the air near the earth is "thicker," a notion which he evidently derived from his observations of distant hills, which are made to appear blue by Rayleigh scattering in the intervening atmosphere.

On the other hand his treatise on shadow and light is first-class. He realises the existence of the umbra and penumbra of a shadow when the source of light is an extended one. Fig. 1, reproduced from his account, shows that he realises that a point such as *h* is in complete shadow, whereas a point such as *g* is only in relative shadow, part of the extended source *bedca* being visible from it. His actual diagram does not show the two shadow cones separately, but his distinction of primary and secondary shadows in his written account shows that his ideas were accurate.

But his interest was on the whole that of a painter, and although he gives examples, such as Fig. 2, to show how a dark enclosed space may be illuminated by repeated reflection of the sun's rays, a good many of his examples are artistic ones. To illustrate how the lighting of a surface depends on the angles at which the rays strike he takes a grotesque face (Fig. 3), and he drew many figures of the same kind, such as those of Fig. 4, on whose jutting chins and dome-like foreheads he could study the play of light and shade according to the principles which he had worked out.

FIG. 4

He applies the same principles to the representation of mountains and of foliage, in the latter case pointing out that, if there are several layers of leaves between the eye and the source of light, then those nearest to the eye will appear the darkest.

This volume is not a scientific treatise and was not intended to be, but it is the work of a scientific mind which can be read with interest and pleasure to-day even by those whose interests are not primarily artistic.

REFERENCE:

Telepathy. By WHATELY CARINGTON; (London, Methuen, 1945).

Spanish Edition of "Discovery"

OUR readers may be interested to learn that from April DISCOVERY was printed in Spanish and published in both Latin-America and Spain, as well as Spanish Morocco, and the Balearic and Canary Isles. We believe that this edition will do much to promote international interest in scientific progress among the Spanish-speaking countries. We hope, too, that scientific workers in the countries which the Spanish edition reaches will send us occasional reports of their work which will be considered for publication in the English edition. We believe that in this way DISCOVERY will serve a useful international purpose.

Post-War Plastics

PAUL I. SMITH

PLASTICS have captured the imagination, if not entirely the credulity of the British public, though, as a result of garbled and exaggerated accounts of the properties and prospects of these materials, a somewhat confused idea remains as to their immediate future. The Plastics Age is not scheduled for to-morrow nor, indeed, for many to-morrows—it is likely it will have to be postponed until new sources of cheap and abundant raw materials become available. No one can doubt the rich future for plastics, but it can only be assured as the result of intensive research carried out by all branches of the industry.

The raw materials for plastics production are drawn from three main sources—coal, petroleum and agricultural surpluses; in some cases plastics can be derived from waste products. Great Britain to-day depends largely on two domestic industries to supply the intermediate chemicals needed for the manufacture of plastics: tar distillation which produces phenol, cresols and benzene, and the synthetic nitrogen industry which makes available urea. Phenol and cresylic acid from coal tar, and formaldehyde derived from methane (itself dependent on coal by-products), are used in the manufacture of the phenol formaldehyde or Bakelite type of resin. (Phenol can also be produced synthetically from coal tar benzene). Urea and formaldehyde react to form urea formaldehyde resins of which Beetle and Scarab are the best known commercial types. The two classes of synthetic resins mentioned above constitute the most important thermo-setting or thermo-hardening plastics.

Turning to the thermo-plastic materials, it is convenient to consider them under two broad headings—*neo-synthetic* and *true synthetics*. The first named are the cellulose plastics, such as celluloid or xylonite, cellulose acetate and cellulose ethers, all of which are made by the chemical treatment of pure cellulose obtained from cotton linters. The chemicals employed for the conversion of the white and fluffy cotton linters into transparent cellulose acetate are acetic acid and acetic anhydride, two chemicals derived from the alcohol produced by the fermentation of molasses or, alternatively, from acetylene. The true synthetics, such as polyvinyl chloride (P.V.C.), polyvinyl acetate and polyvinyl alcohol, all these are derived from acetylene or ethylene gases. Polythene, the important new plastic made by I.C.I., is formed from ethylene derived from alcohol; polystrene from alcohol and benzene; acrylic resins, such as Perspex, from acetone, also made from alcohol or molasses.

It is thus apparent that Britain, although practically self-sufficient so far as the manufacture of thermo-setting resins from tar acids and formaldehyde is concerned and to a limited extent in respect of nylon made from benzene, is dependent on imports of raw materials or intermediates for the thermo-plastic section of the industry. Molasses for the fermentation industry has to be shipped to this country to prepare industrial alcohol, the key chemical for so many synthetic processes. Unfortunately Britain has not yet developed a carbide industry on any large scale, and in consequence it is necessary to impart carbide for the manufacture of the acetylene, or to produce the monomers—such as vinyl chloride—from the gas ethylene *via* alcohol.

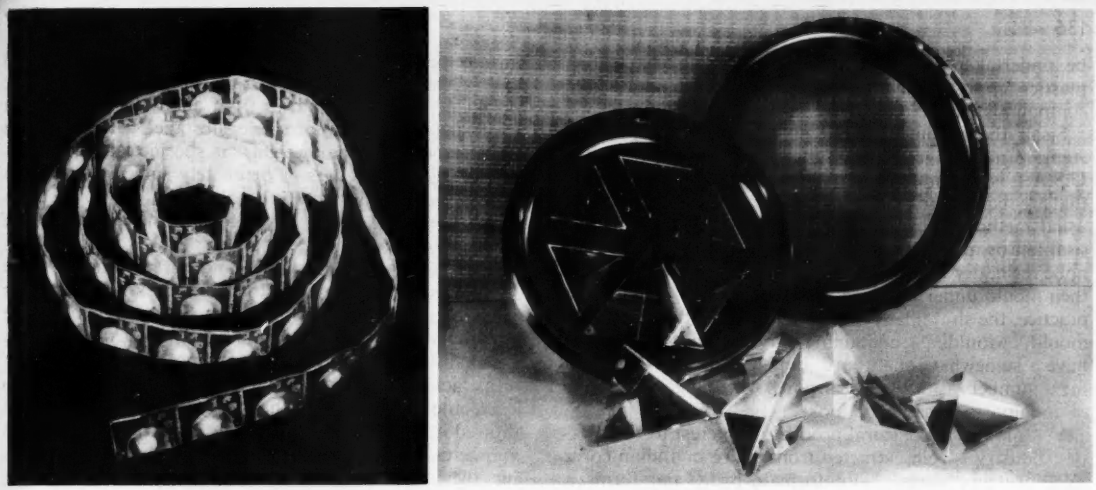
Acetylene, the touchstone for so many plastics, can only be made on an economically sound basis where there are cheap coal (to provide the coke or carbon), lime and an abundant source of electrical power (needed for fusing the coke and lime to make calcium carbide). Britain lacks cheap coal, and has so far not found it possible to develop hydro-electric power schemes on any really large scale. Canada early realised the value of hydro-electric power and during the last twenty years has, by making available cheap electrical power, built up a prosperous synthetic chemical industry based mainly on acetylene. Large quantities of acetic acid, acetic anhydride and vinyl resins—all made from acetylene—have been sent to this country from Canada.

Turning briefly to petroleum, one finds that America has built up a new chemical industry around refinery gases and the byproducts from cracking plants; it is claimed that more than 300 organic chemicals are to-day being made from petroleum. It is no exaggeration to say that all the plastics now in use can be made from petroleum or its byproducts: phenol, for the Bakelite type of resin, can be derived from this source instead of from coal tar; acetone, alcohols, styrene, formaldehyde and glycerine can all be made from refinery gases. It is unfortunate that this country has not built up a petroleum refinery industry and adopted the policy of importing crude oil instead of finished products; possibly the increasing yield from our own oil wells in the Midlands will encourage the Government to develop refineries and cracking plants on a large scale after the war.

Plastics from Farm Crops

Chemurgy, which has been defined as a study of the conversion of agricultural surpluses and waste products into the raw materials of the chemical industry, offers great possibilities for Britain as the Empire is singularly rich in all those natural materials likely to be most useful for plastics manufacture. Alcohol, a chemical vital to the industry, is made in this country by the fermentation of molasses, but it could be produced by the fermentation of potatoes, corn and other cereals, as well as from sugar made from sawdust. The last named source is of the greatest importance as it has long been considered that although theoretically possible the yield was so small as to render any method based on cellulose to be uneconomical. The Scholler-Tornesch process is now being operated in the United States on a considerable scale and it is claimed to be responsible for large quantities of much needed alcohol.

Apart from making chemicals from agricultural products, it is possible to convert some of them into plastics by direct chemical treatment. Lignin present in several



War-time uses for two plastics that have great post-war possibilities. (*Left*) The polythene packaging in which mepacrine tablets are supplied to our troops serving in regions where malaria is rife; the polythene film of which the strips are made is only 1-250th inch thick, but it protects the drug from deterioration in damp tropical heat. (*Right*) These optical prisms are made of Transpex, a special variety of the methyl methacrylate resin known as Perspex.

waste materials, such as sulphite cellulose liquors from paper manufacture, reacts fairly readily with various chemicals, such as phenol and aniline, to form resinous products, some of which are being employed for moulding and varnishes. One well-known American lignin resin (Lignolite) has a tensile strength, 7,500-12,000 lb. per sq. in. and possesses valuable electrical properties.

A most interesting and important new type of resin is derived from the cashew nut, which is grown in Southern India, South East Africa, Brazil and Central America. Large quantities of cashew nut kernels are eaten as dessert in America, and in India a large industry has grown up employing over 50,000 people to deal with the trade. At one time the nutshell liquid was considered to be an undesirable byproduct of the industry but, as a result of research work carried out in America by the Harvel Corporation, it has become a very valuable raw material in the manufacture of numerous industrial products. The main constituents of this liquid is phenolic in nature, and the peculiar substituted phenol has been named "Cardanol". Resinous materials are made by treatment of "Cardanol" or nutshell liquid with aldehydes or by heating under special conditions. In some cases a resin is made by a combination of the two processes. Cashew nut resins are in general thermo-hardening but when fully cured the resin is somewhat flexible and rubbery, unlike the conventional phenol formaldehyde resin which in its cured state is inclined to be very brittle. This important property has led to the use of cashew resins in fields where other thermo-hardening resins are unsuitable. Some of the uses to which they have been put are in insulating varnishes, synthetic rubbers, cold-setting filling compounds and cements, brake linings, industrial floorings and linings, insecticides and laminating work.

One of the most interesting of the agricultural products that are useful to the plastics industry is the soya bean, which yields a prodigious crop in many parts of the world. The soya bean is a valuable source of protein; but besides yielding a rich food and oil, it also makes available a raw material which, coupled with phenol formaldehyde resin, can be used for the preparation of a strong plastic. The method of manufacture as carried out in America depends upon the use of soya-bean meal from which the oil has been extracted by solvents. This is mixed with freshly-made phenol formaldehyde resin and wood flour, and the three materials are thoroughly mixed, dried, ground and screened to give a commercial moulding powder comparable with standard grades as regards strength (its moisture resistance is somewhat inferior) and a good deal cheaper to produce. Henry Ford has sponsored a good deal of the development work on soya-bean plastics, and has made use of certain car mouldings of this material as well as employing soya-bean wool for upholstery purposes. Laminated soya-bean plastics can be produced by impregnating paper with a water dispersion of the soya-bean protein, drying the sheets and then consolidating them in a hydraulic press so as to effect a "cure" and to bond them together. Boards manufactured in this way are claimed to be tough and comparable on a strength basis with those made with phenolic resin.

Another material of growing interest is bagasse, the residue remaining after the extraction of the juice from the sugar cane. This fibrous material has a chemical analysis (by weight) of 18% lignin, 45% cellulose, 15% water-soluble matter and the remainder hemi-cellulose (a degradation product of pure cellulose). Much of the early development work on this natural waste product was carried out by the Agricultural Byproducts Laboratory, Iowa, U.S.A., and just prior to the outbreak of war bagasse had been converted into two forms of great interest to the plastics industry—a pure bagasse resin and a filler made from the fibrous part of the material. To-day an appreciable tonnage of bagasse moulding-compounds are being made in America, but owing to the shortage of chemicals required for making the bagasse resin these are now being formed from 70% processed bagasse and a resin made from non-essential chemicals. The compounds are all thermo-plastic and soften at 350-400° F. Sugar cane is grown extensively in the Empire and there seems to be no reason why development work on bagasse should not

be undertaken so as to make available to the British plastics industry a new source of cheap moulding compounds.

Sisal, the fibrous material obtained from the leaf of *Agave sisalana* (grown in Tanganyika, Mexico and the U.S.A.) is an important reinforcing agent for plastics that are required to resist very heavy impact or shock. The usual method of using the material is to impregnate the sisal felt or matted sheet with a solvent solution of a phenolic resin, dry it so as to drive off the volatile solvent and then mould under heat and pressure. In actual moulding practice, the sisal filler is roughly shaped to the size of the mould. Mouldings containing large quantities of sisal have a somewhat rough finish but they are quite suitable for a number of industrial purposes where high strength is more important than good looks.

Yet another agricultural product of interest to the plastics industry is zein extracted from maize or Indian corn. Zein protein "cures" with formaldehyde, and forms a useful resinous compound, which has been used with shellac to make scratchless gramophone records and appears to be of interest to the paint and varnish industry. Plastics produced from potatoes, using the waste material left behind after the removal of starch, have been made experimentally at the College of Idaho, U.S.A., and after plasticising can be moulded under heat and pressure; with the addition of some fibrous reinforcement, they can be moulded into insulating type building board. It has been claimed that plastics can be made from citrus waste, and American sources state that one type of material, with a tensile strength of 10–18,000 lb. per sq. in., can be moulded and cured without heat or pressure.

Finally in connection with chemurgic products, mention should be made of furfural obtained from oat hulls thrown out as a waste product by manufacturers of breakfast foods. The quantity of oat hulls available for chemical treatment to produce furfural is considerable, and one American plant alone turns out as much as 200 tons a day. The hulls are subjected to the action of steam and acid in large rotary digesters, and the distillate from these digesters, which has a high furfural content, is neutralised with lime and the furfural recovered by distillation. Phenol furfuraldehyde resins are not yet produced in Britain to any extent, but they offer a useful addition to the range of thermo-setting compounds. Furfural plastics are produced on a fairly large scale in America.

Polymerisation

Polymerisation is the chemical combination of a number of similar molecules to form a single large molecule whose molecular weight is a multiple of that of the original substance. The substance with the large molecule (known as a macromolecule) is called a *polymer* and the smaller molecule from it is derived a *monomer*. An example to hand of polymerisation is the formation of polystyrene from styrene, the latter being a colourless liquid boiling at 146°C. The number of monomer or styrene units in the polystyrene molecule depends upon the conditions of polymerisation, such as temperature, purity of the monomer and the presence of chemicals (sometimes impurities) capable of retarding polymerisation. If the styrene is heated at too high a temperature a brittle and very hard form of polystyrene is produced; if the temperature is too low, a softer grade of material results. The molecular weight of polystyrene varies from about 1000 to as high as 300,000, and each polymeric substance with a separate and distinct molecular weight has specific and characteristic physical properties. Fortunately sufficient is known about the mechanism of polymerisation to enable works chemists to ensure uniformity of output, but it can be appreciated that the process makes it possible to produce an almost indefinite range of materials; these plastics, in fact, can be made to measure. W. H. Carothers in his classic researches on the polyamides (nylon is the generic term for all fibre-forming polyamides) found that the chain length of the polymers produced by reacting adipic acid or similar organic chemicals with hexamethylene could be so adjusted that the viscosity of the product allowed it to be drawn into threads. The range of possible commercial grades of polyamides formed by modifying the conditions of polymerisation is almost unlimited.

Not only can polymerisation of single substances or monomers be made to produce many industrially useful materials, but mixtures of similar substances can be polymerised, the process being known as co-polymerisation. The best known co-polymers are those made by polymerising a mixture of vinyl chloride and vinyl acetate, the former being present in the larger proportion. The polyvinyl co-polymers (like plain polyvinyl chloride) are used extensively instead of rubber for covering wire and cables.

Orientation

Polymerisation, a purely chemical process, converts relatively simple molecules into bunches or chains which form a polymer. The use of a purely physical process, such as cold drawing of fibre-forming polymers, such as nylon and polythene, orientates or adjusts these molecules in a regular manner. Carothers found that after spinning nylon fibre could be stretched and drawn to give greatly increased strength and elasticity. On stretching polythene there is a marked increase in the tensile strength up to 15,000 lb. per sq. in. X-ray analysis and examination in polarised light show that this is associated with an orientation of the chain hydrocarbon molecules, which are pulled into side-by-side position during cold drawing and are so enabled to exert their maximum strength in the direction of their length. The process of manufacturing polythene film is such that there is some orientation of the molecules along the film, and consequently the strength is greater in this direction than it is across the film. Polystyrene is another plastic capable of being greatly improved by operations which stretch the polymer during cooling, and the impact strength and elongation before tensile break are considerably increased. Up till now only the fringe of this orientation technique has been reached and the future may well witness the physical treatment of high polymers designed to arrange the molecules so as to exaggerate any particular physical property. The chemist will make the large molecules for the physicist to arrange into special kinds of molecular order or pattern (each pattern can be disclosed by X-ray or polarised light), each being suitable for a particular type of application.

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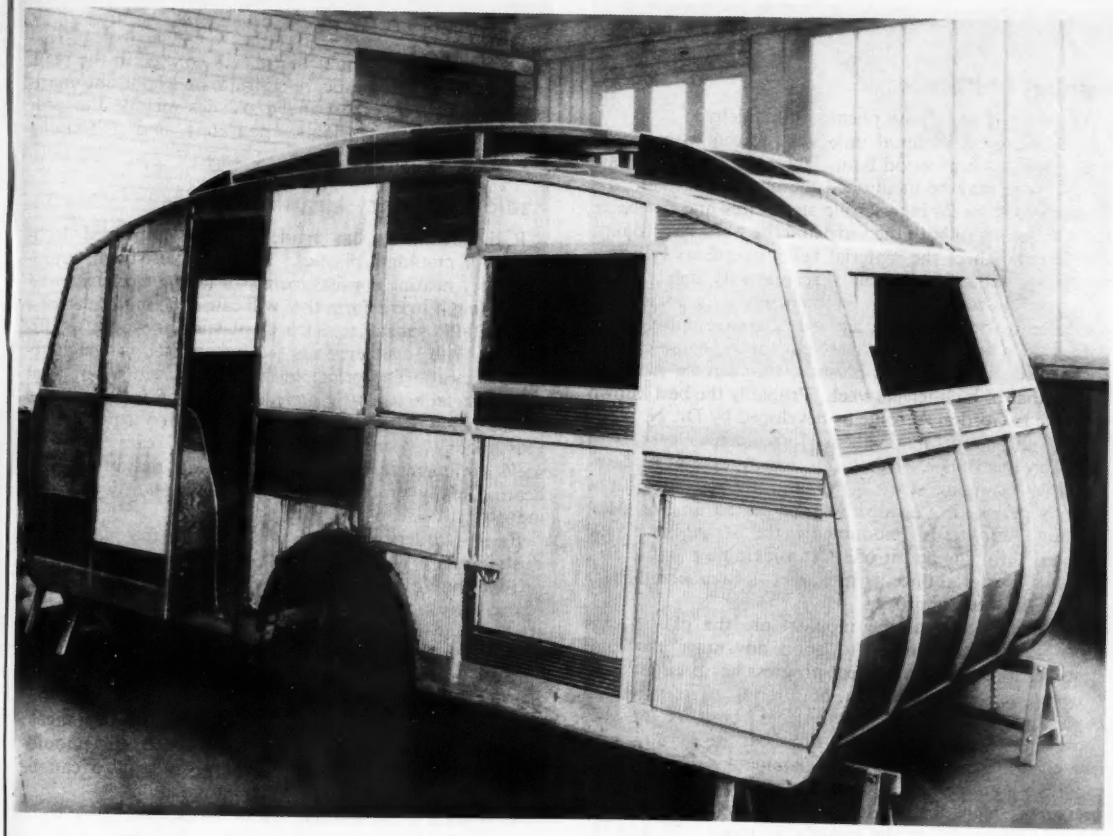
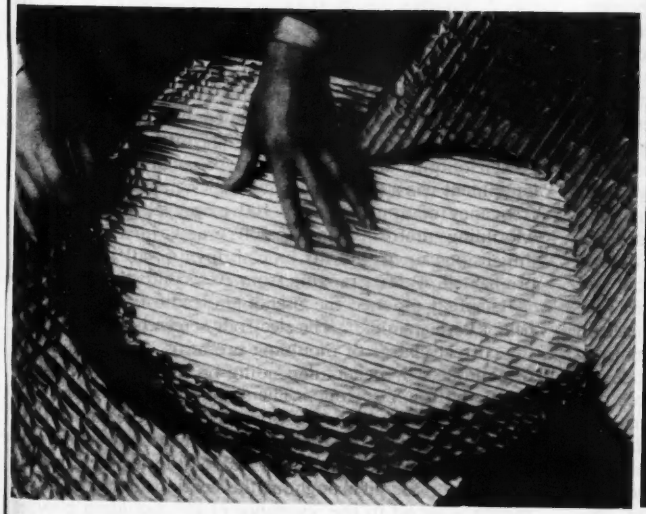


THE plastics industry is a source of new insulating materials. The caravan shown in the photograph is lined with pads of Isoflex cellulose acetate which keeps the heat in. The ease with which the corrugated sheets can be cut to shape and fixed is illustrated below.



Reinforced Plastics

Synthetic resin of the phenol formaldehyde type is a brittle and weak material unless reinforced with fibrous substances, such as wood flour, fabric, asbestos and glass fibres; here may be mentioned the new metal-reinforced fabrics based on 24 high-tensile steel wires and cotton to the inch woven in both the warp and the weft, the ultimate tensile strength of the material being over 24,000 lb. per sq. in., and the impact strength exceptionally high.

By the discreet use of reinforcements it is possible to produce moulded and laminated thermo-setting resins with a very high strength-to-weight ratio; in the case of some specially reinforced plastics, this can be made to exceed that of high-tensile steel. Probably the best known example is Gordon Aerolite as developed by Dr. N. A. de Bruyne and consisting of phenol formaldehyde resin with unwoven linen filler. This has a density of 1·47 as compared with stainless steel at 7·85, and a tensile strength of 30 tons per sq. in., against 80 tons per sq. in. for steel. Gordon Aerolite is undoubtedly the strongest plastic material yet made and it offers considerable promise as a structural material once its resistance to fatigue and shear stresses has been improved.

Of great interest at the moment are the plastic-glass composites, which utilise to good advantage the high strength of glass fibres. Great progress has been made in America in the production of aircraft parts moulded from this type of material, the glass consisting of fine, short glass fibres known as Fiberglas flock, and heat treated Fiberglas fabrics. The laminated sheet can be moulded into intricate forms without the use of high pressures, high temperatures or costly steel moulds; the specific gravity of the material is about 1·75, and the tensile strength is 43,360—54,720 lb. per sq. in.

Expanded Plastics

These new additions to the range of plastics consist of thermo-setting and thermo-plastic materials expanded by a special process so as to produce substances with a unique cellular structure and very low density. Expanded phenol formaldehyde resin, or Thermazote, is manufactured in densities between 7 and 30 lb. per cubic foot; expanded polyvinyl formal; expanded polystyrene is made at 2 to 20 lb. per cubic foot. These materials possess reasonably good mechanical strength; at its lowest density. Thermazote has a compression strength of approximately 100 lb. per sq. in. The thermal insulating properties of all the expanded plastics is exceptionally good. Expanded plastics are to-day being used for constructional purposes and find extensive application as a low-density, elastic stabilising medium for sandwich construction in aircraft, particularly when veneered with plywood and light metals. Expanded phenolic resin veneered with plywood and asbestos cement sheet is also being used in building practice and has the great advantage of combining excellent constructional features with a very high degree of thermal insulation. In combination with steel and asbestos cement, such a material as Thermazote is ideal for the pre-fabrication of houses and it has been incorporated into a number of experimental houses.

Expanded plastics are also in demand by the refrigeration industry for lining meat, fruit and ice-cream vans; after the war there is no doubt that it will be used in the mass production of domestic refrigerators. Important maritime applications of expanded plastics include the production of buoys, floats, pontoons and life-saving apparatus.

Radio-Frequency Heating

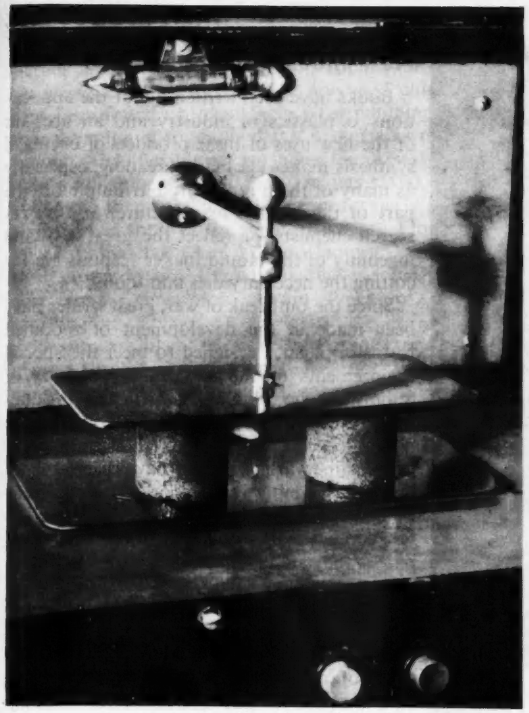
Radio-frequency has made possible improved techniques of moulding plastics. In its simplest form, radio-frequency heating consists merely of taking electricity and converting it into a form that will cause the molecules of a non-metallic substance, such as plastics or wood, to distort and rub together, thus setting up friction which results in heat. The principle involved in generating heat within the substance by molecular friction is not by any means new—it has in fact been known for a number of years—but it is only within the last few years that large scale commercial equipment rendering radio-frequency heating really practical has been put at the disposal of industry.

Radio-frequency heating is applied to the plastics industry in two ways; first and most important being the pre-heating of thermo-setting moulding compounds, particularly phenol formaldehyde resins, and the second, the welding of thermo-plastic sheet materials. Dealing with the pre-heating of moulding powder, either as preforms (i.e. compressed pellets or tablets) or as loose powder, it has been found as the result of experience that radio-frequency heating offers the following practical advantages:

1. It greatly reduces the time needed for moulding or "curing" (hardening); the pressure also can be reduced.
2. It reduces the internal stresses which are liable to be set up during ordinary moulding, frequently causing warping and cracking of mouldings.
3. As a result of reduced curing time, lower pressure and easier flow, it increases the life of the expensive steel moulds.
4. It ensures that the resin is fully cured or hardened throughout the thickest section of the moulding.
5. It reduces the movement or displacement of metal inserts in the moulding.
6. It renders possible the moulding of very thick sections hitherto considered impossible to produce.

Radio-frequency pre-heaters now in use in the moulding section of the plastics industry are enabling production to be increased by as much as 50%. The sets vary in size and power output, but a popular type such as the Rotol equipment has a power output of 1 kW. and an operating frequency of approximately 100 megacycles per second. Moulding preforms up to 500 grams in weight with dimensions up to 9·0 ins. × 2·5 ins. × 4·0 ins. can be pre-heated in times ranging from 20 seconds to 3 minutes.

In actual practice the use of the radio-frequency pre-heater is very simple. The electrode screen is removed and the correct charge of moulding preforms, perhaps two or three tablets or pellets depending on their size, is placed on the bottom electrode. The screen is then dropped and the unit switched on. A process timer, mechanical or electronic, is fitted by means of which the power is automatically switched off at the end of the pre-determined heating period. (Throughout the heating the set is automatically tuned to the resonance of the moulding powder



(*Above*) Two phenolic resin preforms in position between the electrodes of a radio-frequency preheater. (*Right, top*). A preform of phenolic resin before preheating. (*Right, bottom*). This is a preform that has been heated for 7 seconds in the pre-heater; notice that it has become soft and mushy, so that it is in an ideal condition to flow readily when transferred to the mould.

and the operative does not have to trouble about the electrical complexities of the set.) When the allotted preheating time has expired the set automatically switches off the current, the worker removes the heated preforms or powder and places them in the moulding press nearby, which is immediately closed.

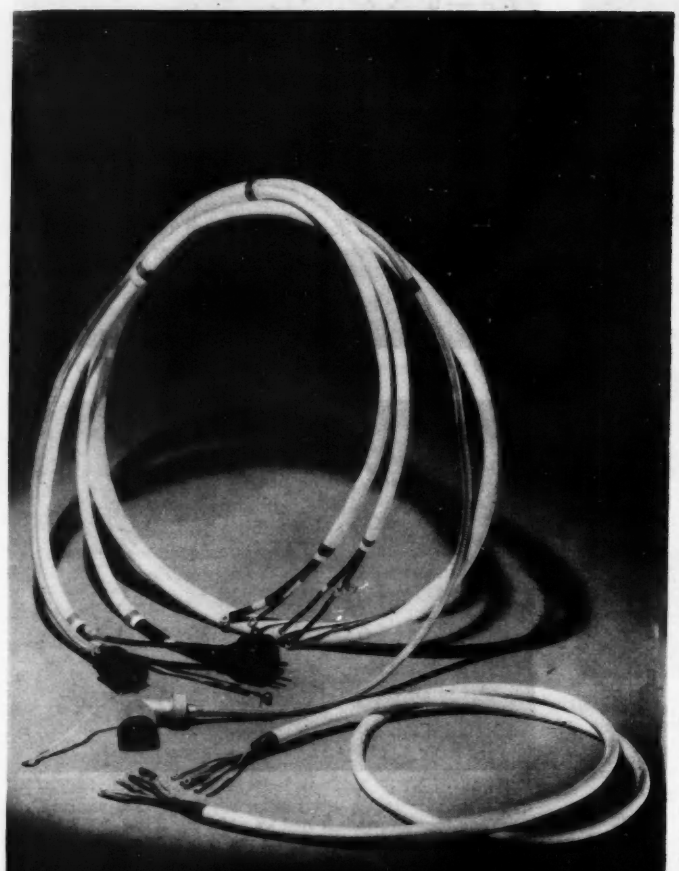
The development of radio-frequency pre-heating has greatly enlarged the scope of modern moulding practice and has rendered possible the economical manufacture of large, thick sections, formerly considered impossible to produce economically. The radio-frequency pre-heater is employed as a separate unit alongside the moulding press, but it would be a great advantage if radio-frequency heating could be used to heat the moulding powder within the steel mould itself just prior to the application of pressure, or during the actual moulding time when the press is closed. This would have the advantage of doing away with an unnecessary operation and further speeding up production. There are, however, considerable difficulties in the way of such a development and it will probably be some time before radio-frequency heating units are actually built into the hydraulic presses.

In the manufacture of compound curved laminated shapes by low pressure or contact moulding it is likely that radio-frequency heating will be adopted as a means of applying the necessary heat to cause the resin to flow and later to harden or polymerise. For this type of work it is usual to employ wooden formers or moulds and it is possible to make these act as electrodes by covering the wood surface with metal foil or spraying with metal.

In the field of thermo-plastics, radio-frequency is used for the welding of sheet material, softening of thermo-plastics so as to enable them to be shaped over wooden formers, and to permit the insertion of metal inserts in thick formed sections. At the present time cable manufacturers appear to be making the most use of radio-frequency heating for the actual joining and repair of polyvinyl chloride cables. Polyvinyl chloride and similar materials are very difficult to heat and weld or join owing to their poor heat transmission and the risk of decomposition when the temperature is held for long between the softening and melting points. By use of radio-frequency heating the temperature may be raised to welding condition in a few seconds and the ends of tubing joined under light pressure. In cable manufacture, particularly, the great advantage of radio-frequency heating is that it enables the heat to be generated just where it is needed to effect a true weld and there is no softening or damage to the neighbouring polyvinyl chloride.

Sheets and formed pieces of Perspex can be successfully welded together by use of radio-frequency heating, but it is necessary to take very careful precautions to avoid excessive heat which causes gas bubbles to form at the welded join and so introduces a possible source of weakness.

The seam welding of thermo-plastics by means of the



Aircraft cable harness made of extruded polyvinyl chloride tubing.

electronic sewing machine is a development of great interest to the textile as well as the plastics industry. The seam welder in use in this country resembles an ordinary sewing machine and the actual welding device consists of two counter-rotating rollers which form the condenser electrodes. The materials to be joined together are overlapped and the overlapping edges run between the two rollers. Thermo-plastic sheets and fabric covered with thermo-plastic can be seamed together at speeds varying from about 12 to 72 inches per minute. The great advantage of this method of joining up water-proof garments and thin plastic sheets is that the welded joint is much stronger than can be obtained by cementing, hot sealing by ordinary means, or sewing.

There is no doubt that radio-frequency heating is a method with great possibilities for the plastics industry, but it is important to remember that the maximum time- and money-saving advantages of the process can only be realised by using it correctly in every application; each heating process requires a definite frequency and power combination.

New Industrial Applications

Books have been written about the applications of plastics in industry and an account of the new uses of these products of chemical synthesis makes fascinating reading, especially as many of them represent a triumph on the part of the plastics manufacturer and his research chemists, or reflect the great skill and ingenuity of the mould maker responsible for cutting the necessary dies and tools.

Since the outbreak of war, great strides have been made in the development of modified forms of plastics designed to meet the special requirements of the Admiralty, Ministry of Supply or the Ministry of Aircraft Production. Phenolic type resins suitable for the moulding of hand grenades and vital parts of certain warlike stores have been made; low loss phenolic resins for insulation purposes, and tasteless and odourless materials for contact with foodstuffs have been prepared; the catalogue of applications is indeed a large one.

Most people are now aware that plastics play an important part in the construction of all types of aircraft and the names of certain types of material, such as Perspex, have become very well known. It is therefore opportune to say something about a material that has contributed generously to the high standard of British service aircraft. Since the early days of the war, cellulose acetate has been used in large quantities for transparent windows, various kinds of fairings, and tubing. Aircraft manufacturers have found Bexoid cellulose acetate tubing of considerable value for solving difficult problems of construction involving the use of oddly-shaped ducts, such as those required to heat the gun in the latest Spitfire. Unlike metal, this plastic tube can be blown to shape in split wooden moulds and given acute bends without the use of special technique or, indeed, any very great skill; manipulation is not only simple, but lends itself to ready modification. There is no doubt that the experience gained in the shaping of cellulose acetate sheet during the war is likely to be exploited to good purpose when hostilities cease, and there will become available an extensive range of acetate goods made by means of inexpensive wooden tools.

Plastics have contributed a great deal to the success of Radar equipment and the use of Distrene (the British form of polystyrene), and polythene, are worthy of special note. Not only have these thermo-plastics been used for making a new type of light-weight and more efficient cable to replace the old coaxial type, but Distrene moulded units have been employed with great success for electrical units because of this material's extremely high dielectric strength, and suitability for use at radio-frequencies. There is no doubt that polystyrene will play a great part in the development of post-war radio and television.

A rapidly increasing quantity of polyvinyl chloride is

being used for cables and wire coverings, coatings for textiles and for certain industrial applications only now becoming known; for instance polyvinyl chloride tubes have been found very satisfactory for pumping beer, milk and other liquid foods, and P.V.C. curtains made of the 5 mm. thick flexible sheets have found service in shot blasting chambers where their use has saved one British firm more than £400 a week, a sum formerly spent in replacing steel sheet of the same thickness. Flooring made of P.V.C. has been laid in food factories, and conveyor belts covered with this plastic have some advantages over rubber ones for certain types of mechanical handling.

Plastics are likely to make important contributions to the post-war building programme, not as load-bearing members (for which they are unsuitable on account of their lack of stiffness and ductility and poor resistance to fatigue) but for certain other important applications where they are either unstressed or lightly stressed. It has already been pointed out that expanded plastics are likely to be used as an elastic stabiliser or for making the centre of a light-weight building unit with asbestos cement, steel or plywood sheets on the outside.

Laminated plastic veneers and wall panels, moulded cisterns and the new extruded cellulose acetate strips used for hiding the joints of building boards in the interior of the pre-fabricated house—all these and more deserve mention, as also do the synthetic adhesives developed from phenol formaldehyde and urea formaldehyde resins which are now being used so extensively for making resin-bonded plywood. The story of plastics in industry is one of truly amazing variety, and in this thumb-nail sketch only a few of the out of the ordinary applications have been introduced, leaving untold the numerous uses of these materials in the engineering, electrical, optical and other important industries.

Ilya Metchnikoff (1845-1916)

UNLIKE Paul Ehrlich of "Magic Bullet" fame, with whom he shared a Nobel Prize in 1908, Ilya Metchnikoff (or Mechnikoff) did not have the limelight of Hollywood turned on his deeds to commemorate the man. Yet this Russian Jew whom Pasteur welcomed in Paris was as strange and flamboyant a character as ever appeared on the scientific scene. Because of his discovery of phagocytes, the "devouring cells" which, like the leucocytes of the blood, "engulfed" the germs of disease, his birth on May 15 a century ago is well worthy of celebration.

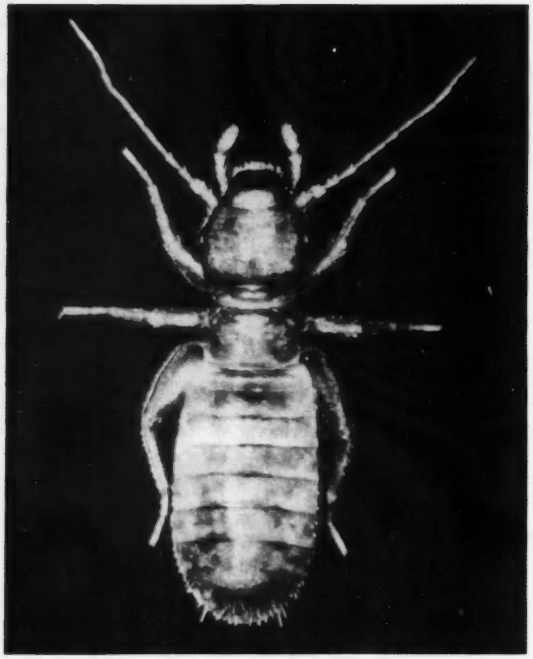
A native and university student of Kharkov, Metchnikoff was during his early career a zoologist of sorts. He grew up in Tsarist Russia "where a gendarme sat astride the halls of learning". After a period in Wurzburg he became *dozent* in zoology conjointly at Leningrad and Odessa, and professor of zoology and comparative anatomy some time later. Yet in Russia according to his views a prophet was not without honour save in his own country. He was ever leaving his native land, going the rounds of university laboratories in Europe, and then returning as the fit took him. "I have zeal and ability, I am naturally talented," he cried in his egotism. In the hysteria of his youth he wrote violent pamphlets, sent pseudo-scientific papers to journals and then suddenly changed his views—"Please do not publish the manuscript I sent you yesterday. I find I have made a mistake." He attempted suicide on a number of occasions; quarrelled with the Odessa University authorities after his second attempt to take his life (unsuccessful, fortunately for pathology); and in 1882 set off for Messina with his second wife, Olga. (His invalid first wife soon passed from him; his second was his mainstay, a recipient of his outbursts, a woman who took up science for his sake.)

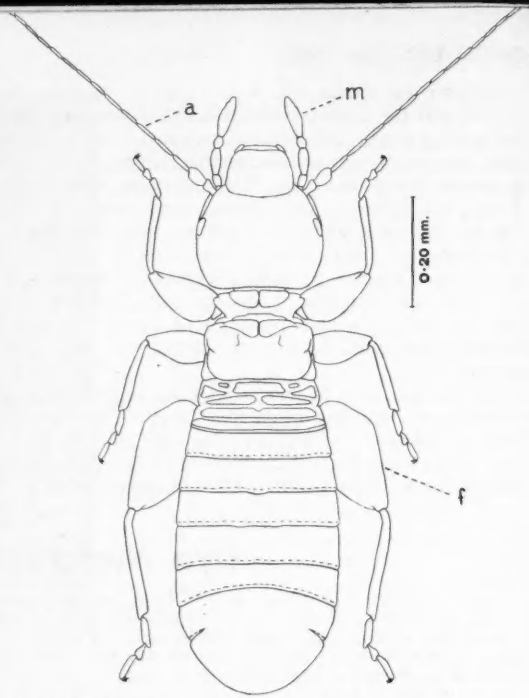
Up to this point Metchnikoff knew little or nothing concerning bacteria. He had studied worms, had accused Leucart of plagiarism, and had been a poor experimentalist. But he had read Darwin's classic. And it was quite possible that to further his profound belief in the survival of the fittest he turned to study germs which attack animals and man. It was in his ill-equipped home laboratory in Sicily that he "suddenly became a pathologist", as he wrote. He observed the digestive organs of sponges and starfish and was struck by the minute wandering cells within the bodies of such creatures. To him came inspiration one day as it came to Leeuwenhoek, that draper of Delft, and to Koch, the country doctor. The dilettante zoologist refused to accompany his wife to a circus at Messina, preferring his starfish larvae to the performing monkeys. He wandered to the sea shore, "to collect his thoughts" as he said afterwards, recounting the incident. But he collected something else. Into the young starfish he pushed some thorns (these he collected from a rose tree that grew in his garden) after staining their transparent cells with carmine. Despite the lack of a nervous system, the mesodermic cells he noticed to accumulate round the thorn—just as white blood cells of the human body gather round a splinter. Metchnikoff observed how these "devouring" cells took in particles of carmine and other foreign bodies. In some cases he maintained (he excelled at guessing in advance) that germs were dissolved by the devouring cells; in others they were carried away from the wound. He lacked full experimental evidence, yet the phagocytosis theory of immunity was born.

Metchnikoff hastened to Claus in Vienna and to Odessa to proclaim his theory of the friendly phagocytes, and was soon on the platform lecturing on "The Curative Forces of the Organism". He had not actually seen harmful bacteria consumed by his friendly cells. But just as Leeuwenhoek examined drops of water for little animals "a thousand times smaller than the eye of a louse", so did Metchnikoff find his subject in water fleas. He watched the spores of a mould swallowed by water fleas being absorbed by phagocytes; and when such cells failed to function, the insect succumbed to the mould. After another spell at Odessa where he failed to hold a post as scientific adviser, Metchnikoff went to Pasteur in Paris and was accommodated with a laboratory first at the École Normale and then at the Pasteur Institute. His wife at this period helped him when his fingers were too impatient, just as Marie Antoinette Lavoisier helped her chemist-husband at the Arsenal. His theory of immunity was accepted in France but denounced by Koch, Ehrlich and others in Germany and Austria—Ehrlich had the idea that immunity depended on the chemical properties of the blood. Yet by 1892 his views were fully recognised and he enticed a number of workers to ply their deft fingers in carrying out a number of experiments, no matter how fantastic, which flashed through his mind as he sought to solve the riddle of immunity. He had the Belgian Bordet to work with him for a time, to begin work which led to the Wassermann test for syphilis. He joined hands with Emile Roux, these two being successful in inoculating anthropoid apes with syphilis and in devising treatment with calomel, a treatment to which moralists raised great objection.

In later life Metchnikoff published his *Immunity in Infectious Diseases*; his semi-popular work, *The Nature of Man*; and his *Prolongation of Life*. He held the view that life is unnaturally shortened by intestinal putrefaction, and believed in lactic ferments as a remedy. To benefit from the lactic "Bulgarian bacilli" he consumed gallons of sour milk. And though he passed to remarkable studies of bacteria affecting the alimentary canal, became a Nobel Laureate, and contributed much to the bringing of bacteriology to the aid of therapeutics, Metchnikoff will be remembered as a man with fantastic ideas; a man who thought of gerontology, the science of old age, and of thanatology, the science of death. One pet idea of his is supported by the sophisticated university student of to-day, viz. that it is better to work inspired by the presence of pretty girls in the laboratory!

M. SCHOFIELD.





FIGS. 1 and 2.—The photograph shows an adult booklouse, *Liposcelis granicola*. (Photograph by W. S. Richards). Details of structure are seen in the diagram; *a*, antenna; *f*, swollen femur of hind leg; *m*, maxillary palp.

The Booklouse

E. BROADHEAD, B.Sc., M.A., F.R.E.S., and B. M. HOBBY, M.A., D.Phil., F.R.E.S.

IT IS the intriguing occupation of the naturalist to study the ways of life of all kinds of animals both large and small and to understand how they feed, how they hunt their prey, how they avoid capture by their enemies and how they reproduce their kind. Many of these creatures can be observed and studied relatively easily in their natural haunts. Often with the smallest animals it is better to take them and study their structure and their habits in the laboratory. Thus has been acquired the vast collection of knowledge to which we turn for guidance when animals come into conflict with us in our daily life and become pests. One such pest is the very small and, at first sight, insignificant insect, commonly called the booklouse, a member of the group of insects known as psocids.

In the natural state, booklice spend their lives under the bark of dead trees, hiding in cracks and crannies and feeding upon moulds or the alga *Pleurococcus*, which forms the rich green covering on so many tree trunks and fences. Their flattened bodies and small size enable them to crawl into the narrowest crevices. They are only 1 millimetre long; if placed side by side closely together, no less than six hundred of them could rest on a sixpenny piece.

They have also taken advantage of many habitats created by man, sometimes only too successfully, for given suitable conditions they are capable of multiplying enormously and becoming troublesome. In libraries they may be found between the leaves of books; their food then may be the glue and paste of the bindings. In museums they sometimes cause serious damage by eating the specimens in insect collections. There are probably few houses which do not at some time or another harbour small numbers of these insects on dusty shelves or in cellars where they are not usually observed. Sometimes in new houses they become numerous, and it is thought that they feed on the paste of the wallpaper and on minute moulds growing on the still damp walls. It is, however, in warehouses, in granaries and in ships' holds that they become most conspicuous for here they can breed undisturbed in the warm atmosphere, unhampered by natural enemies and provided with unlimited supplies of food in the form of yeasts and moulds which grow on the grain if it becomes slightly damp. On grain and cereal products they may occur in millions. Even so the amount of foodstuff eaten by them is relatively small, but their presence and possible contribution to the gradual heating of grain, which impairs its properties, considerably depreciate the market value of these products.

Various species of booklice have been studied at Oxford; so far, however, only one of these species, *Liposcelis granicola** Broadhead and Hobby, has been subjected to more detailed investigation.

* Possibly a synonym of *L. divergens* Badonnel, described in 1943 in *Faune de France;* this work only reached England in February, 1945.

The adults of this species (Figs. 1 and 2) are extremely active creatures, with small black eyes, long feelers or antennae and a much swollen femur to the hind legs (Fig. 2, *f*), but with no trace of wings. Thickened hind femora are usually associated with the power of leaping, as for instance in grasshoppers and flea beetles, but in booklice this does not seem to be the case since they apparently never jump.

The eyes of insects are built upon a plan quite different from that found in man and other vertebrates. A typical insect eye is a composite structure, consisting of large numbers, often thousands, of minute "eyes" or ommatidia, all lying closely together. The eyes of booklice, however, are degenerate; there are only a few ommatidia and these are separated from each other by small areas of skin or cuticle. *L. granicola*, for instance, has only seven ommatidia in each eye (Fig. 3).

Although the last mentioned species was bred at Oxford for many generations and closely observed, no male was seen. The females lay unfertilised eggs which develop normally. Males are present, however, in closely related species. The adult females walk about with a quick jerky motion, frequently stopping and turning, and when they come into contact with any suitable stimulus such as a moving animal a curious avoiding reaction is invoked whereby they suddenly dart backwards extremely rapidly, after which the slower forward movement is resumed, sometimes in the same, sometimes in another direction. When numbers of booklice running about on a sheet of paper are blown upon they immediately stop running and remain quite still until the blowing ceases.

They often clean their antennae (Fig. 2, *a*) and the tips of their legs, and for this purpose they use their mouth-parts. One antenna only is cleaned at a time; this is bent over and held back by the fore-legs so that it is gradually passed through the mouth-parts which remove bits of dirt. The legs are drawn up beneath the body to bring the tips into contact with the mouth, so that the claws at their ends can be cleaned. Antennae and claws must be kept free from dirt if they are to function properly, as the former bear important sensory hairs and the latter enable the insect to grip surfaces. The mouth-parts are peculiar in that they contain a strong, cylindrical rod called the maxillary pick (Fig. 4), which bears three teeth at the end. It is embedded deeply in the head, but protrudes in front into the cavity of the mouth and can be extruded a short distance. This rod is present in all psocids, but occurs elsewhere in insects only in a few bird-lice. Its function is not certain. It may, either by a chiselling or by a levering movement, break off small pieces of food that are later crushed by the molar area of the mandibles, but the mandibles themselves seem to be well equipped for such a purpose since they have strong teeth at their extremity. When walking about, the booklouse moves its antennae from side to side, and feels the surface in front of it with its maxillary palps which lie on either side of the mouth (Fig. 2, *m*). When it finds a suitable piece of food it stops and takes a bite with its mandibles, and the two palps are used somewhat in the manner of paws or hands, to hold the food and push it towards the mouth. As the animal is semi-transparent, the process of eating and swallowing the food can be observed directly.

Many of the accounts of these insects recorded at the beginning of the 18th century referred to the ticking sound alleged to be produced by them, and the term "death watch" was applied. Such ticking would probably have been produced by the death watch beetle, but a psocid with the name of *Trogium pulsatorium* L., which is common in houses, has the power of producing a faint rapping noise, especially on paper. This is done by a very rapid elevation and depression of the abdomen, so that it taps against the surface on which the insect is resting. This species was for long confused with the related genus, *Liposcelis*, which, it appears, never produces such a sound.

The Insect's Courtship

Many insects have most elaborate courtship displays, and the courtship of *Liposcelis*, though not as intricate as in many insects, is nevertheless very interesting to watch. *Liposcelis granicola*, being parthenogenetic, is of course unsuitable for this, but an allied species has both males and females and its mating behaviour may easily be observed by introducing a virgin female and a male into a small observation cell. Both male and female walk around the cell for some time until they accidentally meet or approach each other to within 2 to 3 millimetres. At this distance the male appears to sense the presence of the female for he suddenly stops running and vibrates his antennae very rapidly through an angle of about 40° for two or three seconds. The female may respond by vibrating her antennae in a similar manner, or she may remain apparently unaffected and walk away until the male has made a number of advances. In the meantime, the male becomes very active and makes short, jerky runs around her, stopping at intervals to vibrate his antennae. Finally he approaches her from behind or from the side, runs over her in a forward direction and then makes a quick, shuffling movement backwards, bringing himself underneath the body of the female, both animals facing in the same direction, and mating is then effected. This may last for ten minutes to over an hour, during which period the female walks about dragging the smaller male behind her; then they separate.

The minute size and agility of these animals make observation difficult, unless special observation cells are used. These were constructed by sticking fine, black bolting silk over microscope slides bored with a small hole, the silk forming the floor, and a coverslip forming the roof. A small cylindrical chamber 1 centimetre in diameter and 2 millimetres high was thus produced, and it was found that by keeping such slides over saturated salt solution in a vessel with a plate glass top sealed with vaseline the booklice could be maintained in the cell at constant humidity while allowing easy observation without disturbing the humidity equilibrium inside. These glass slides were later replaced by thin duralumin strips six inches long and one inch wide, each bored with six holes (Fig. 5). These were much easier to make and had the additional advantage of conserving space in the constant-humidity vessels. This apparatus was well adapted both for observations on the life history and for nutrition work.

There are about seven species of *Liposcelis* occurring in Britain, either in the open or in houses and granaries in stored foods; a few of these are not native but have been introduced into this country recently. The majority of known species have been given only the barest of des-

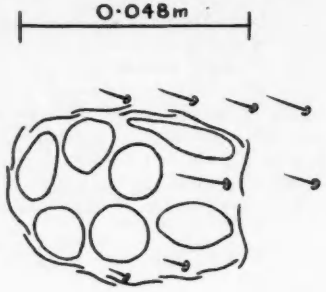


FIG. 3.—Eye, composed of seven ommatidia.

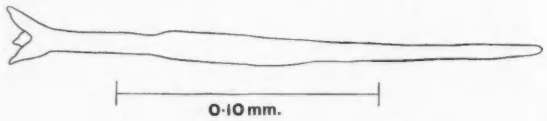


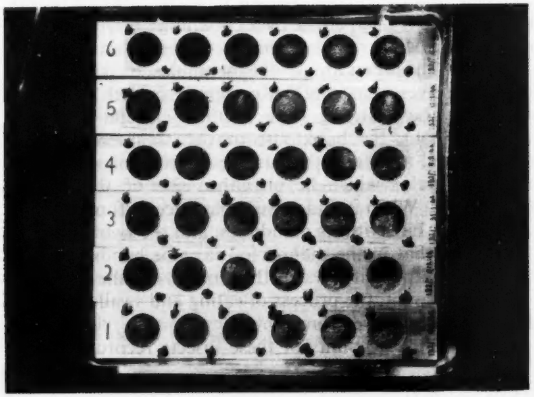
FIG. 4.—Maxillary pick.

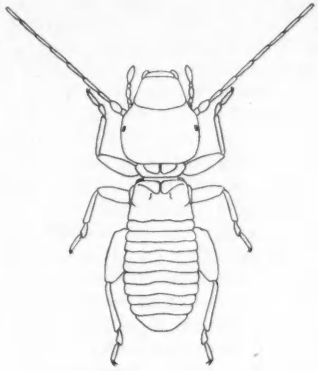
criptions, but the forms occurring in Britain are known in more detail and provide interesting taxonomic material in that specific characters are not well defined, and, of such characters amenable to measurement, there is a considerable variability. In these cases, although the mean measurements are significantly different, there is a considerable overlapping in the different species, and the identification of single or only small numbers of specimens is thus rendered very difficult. We have here what is probably a complex of species closely interrelated and comparable in many respects to the two forms of the fruit fly *Drosophila pseudoobscura*, and presenting a phenomenon similar to that of the so-called "biological races". "Biological races" of any species of animal are structurally almost indistinguishable from each other, so that from an examination of the morphological characters of a single individual, it may be impossible to state with certainty that this particular individual is of race A or race B; it can only be stated that there is a certain probability of it belonging to any particular race. On the other hand, the behaviour of the individuals of the two races, or their respective lengths of life or rate of egg-laying may be quite different. Although "biological races" are relatively infrequent as far as present knowledge goes, yet they are widely represented among the large groups of the animal kingdom. These considerations enhance the importance of life history observations, especially measurement of the duration of nymphal stages, adult life and reproductive rate, when the animals are maintained under controlled environmental conditions.

The eggs of *Liposcelis granicola* (Fig. 6) are very large compared with the size of the animal, being one third of the length of the body of the adult. The surface of the egg is smooth, of a bluish-pearly lustre and is transparent when viewed under the microscope with transmitted light which renders the mass of yolk granules inside clearly visible. The relatively large size of the egg is a common feature of psocids, although in the winged forms this is not as pronounced as in the apterous or wingless members of the group. The eggs are laid singly. For some time before laying, the female remains quite passive, unless disturbed. There are gentle movements of the body fluids backwards and forwards, and then suddenly these increase in intensity and the egg is extruded. The female resumes her normal activity immediately. The egg at first appears moist, being probably covered with a sticky secretion, but it quickly dries and is then firmly fixed to the surface. Some eggs remain completely naked, but others are coated with bits of foreign matter and fæces, which may be brought from a distance. One female that was kept under observation laid an egg in the centre of a small cell, and covered it with red emery dust which she brought from the edge of the cell. Sometimes the eggs are coated with fæces alone, at other times with various fragments of food or rubbish. The females commence egg laying a few days after they have become adults, and the eggs are then laid at a more or less uniform rate if temperature, humidity and food conditions are constant. When yeast (in the form of crushed Aluzyme tablets) is used as the food, a single female lays initially an average of three eggs a day, but this number gradually diminishes as the female gets older, until finally the eggs are laid at a rate of less than one a week. This steady oviposition over the whole life-time of the adult is comparatively rare among insects, and is not met with even in the winged psocids which usually lay small clusters of eggs; in some species of booklice, though not in *Liposcelis*, these clusters are then covered over with a small silken web. (Incidentally the production of silk by an adult insect is exceptionally rare, the silk of commerce being spun by the immature stage—the caterpillar—of the silkworm moth.)

Most insects fall into one of two great groups according to the nature of their development. In one of these the young, known as *nymphs*, do not differ greatly from the adults and the developmental stages are passed through without any pronounced metamorphosis; a familiar example of this is the grasshopper. The psocids also belong to this group. The other division includes butterflies and moths, and the young stage is a caterpillar or grub that is quite different from the adult in form and habits.

FIG. 5.—Observation cells in constant-humidity vessels over saturated salt solution.





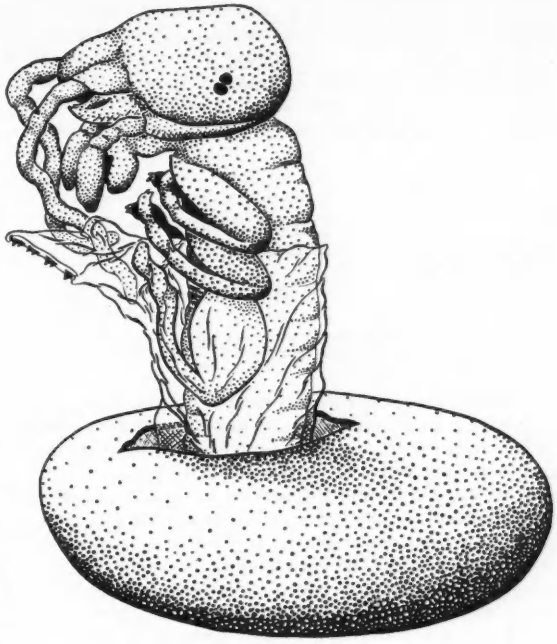
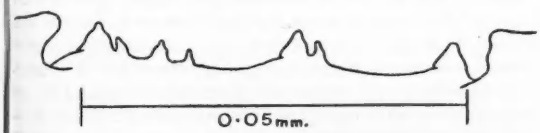


FIG. 8.—(*right*) Nymph emerging from egg. Note membrane with egg-burster. FIG. 9.—(*above*) Young nymph (same scale as Fig. 2).

Just before the nymph hatches, the egg of the booklouse becomes brown, and the red pigment of the eyes of the developing embryo can be seen through the egg shell. This embryo is equipped with a peculiar hatching mechanism, the egg-burster (Fig. 7). This structure, varying in details in the different species, is found in many psocids; a similar organ has been independently evolved many times in the Arthropods, since it occurs in such diverse organisms as the embryos of fleas, certain lacewings, spiders, centipedes and earwigs. In *Liposcelis granicola*, the egg-burster is a hardened file with seven teeth borne over the head on a fine membrane which completely invests the nymph before hatching. The region of the head immediately below the file pulsates and thus forces the teeth through the egg shell. The young nymph swallows air bubbles, and the resulting increase in volume, together with wriggling movements of the body, enables the nymph to burst open the membrane carrying the file, and pass head foremost through the slit in the egg shell (Fig. 8). The young nymph (Fig. 9) is white, semi-transparent, and like a miniature adult, but much more delicate. It starts feeding immediately, and after three or four days changes its skin and so passes into the second instar. There are four such moults, and at the last one it emerges as the adult. The eyes of the newly hatched nymphs are red and consist of two ommatidia only. Additional ommatidia appear at the various moults, and during the life of the nymph, the eyes gradually darken until finally they are black in the adult.



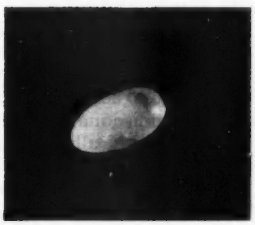


FIG. 6.—(*right*) Egg of *L. granicola*. FIG. 7.—(*above*) Egg-burster.

Diet and Egg-laying

The egg takes 11 days to hatch when kept at 25°C. and 76% relative humidity. When yeast (crushed "Aluzyme" tablets) is given as food under these conditions of temperature and humidity, the nymph develops very quickly—it becomes adult in 15 days—and the adult lives about 6 months. During this period the female is continuously laying eggs. A single female lays over 200 eggs during her lifetime. Considering this quick development and the long adult life, it is easy to imagine how these animals may give rise to enormous numbers of offspring in a single season. In the laboratory, *Liposcelis granicola* was allowed to grow on different foods. The best food, the one on which it grew quickest and laid most eggs, was yeast. Wholemeal flour was not as good, but was much improved by the addition of mould. When given a better food this insect responds very quickly by laying more eggs. Individuals which had been fed for 6 months on wholemeal flour alone were given flour *plus* mould. The result was quite dramatic. After 6 months on flour, they were laying on an average only one egg in two weeks; after feeding on the new food for 24 hours, they were laying, on an average, one egg every two days. These laboratory results are interesting because they may throw light on what actually happens in warehouses, where the number of psocids

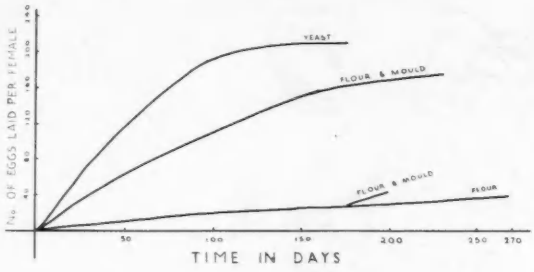


FIG. 10.—Graph showing average length of life and average number of eggs laid when the insects are fed on different diets.

increases if the wheat becomes damp. Although moisture may have a direct effect, it has an important indirect effect in favouring the growth of the moulds which under normal conditions are always present to a small extent on the surface of the grains, and the moulds in their turn favour multiplication of the psocids. The heating of damp grain may also contribute to this increase in number. Inevitable sources of infestation under these conditions are the small populations of booklice which always manage to maintain themselves in grain stored under dry conditions. A relation was also found to exist between the length of adult life and the number of eggs laid during a lifetime on three different foods—yeast, wholemeal flour *plus* mould, and wholemeal flour alone. On the yeast, the female lived the shortest time and laid the largest number of eggs; on the flour, she lived longest and laid the smallest number of eggs; the flour *plus* mould occupied an intermediate position in both these respects (Fig. 10). These observations support the view that certain foods enable the animal to live at a faster rate than do other foods, an index of this being of course the larger number of eggs laid during the animal's lifetime, a phenomenon usually conducive to a shorter life.

Research with Synthetic Diets

The above mentioned foods are all likely to be present in the diet of psocids living in warehouses, but an attempt was also made to construct a "synthetic" diet on which the animal would live and lay eggs. Such synthetic diets have been often attempted with a number of animals; it is one of the more direct ways by which we can learn what sort of vitamins or proteins or carbohydrates are needed by an animal for normal healthy life, and in what amounts. (This knowledge in relation to man himself can only be obtained by more indirect means, since we cannot feed him on a number of synthetic diets and observe the results; our present knowledge of man's nutritional needs, however, has already proved adequate for designing the efficient rationing scheme introduced in this war.) The ideal synthetic diet would be composed of pure compounds of known chemical composition and in themselves as simple as possible. These compounds would consist of laboratory-synthesised amino-acids (to represent the protein requirements), sugars *or* starches, pure fats, and synthetic compounds required only in very small amounts (such as vitamins and sterols). In practice, as near an approximation to this ideal as is possible is attempted, and then by eliminating certain substances one at a time, or by substituting one for another, and observing the results a knowledge of the essential requirements is obtained. A complete synthetic diet, that is one on which the insect will grow and reproduce as rapidly as on its natural food, has not been constructed for any insect as yet, but experiments with synthetic diets are revealing new growth factors, and the laboratory-synthesised amino-acids which have recently been produced will open up new opportunities for the study of protein requirements. For a number of reasons insects are very suitable animals to use with synthetic diets: they require only small amounts of food which in such cases are expensive; the effect of the diet on the insect can be easily measured by counting the eggs laid and by measuring the length of life of the nymphs and adults; they are easy to keep under controlled conditions of temperature and humidity; and lastly they can be kept under aseptic conditions, free from micro-organisms which may play an important part by aiding digestion or supplying certain vitamins. The most suitable insects for this type of work are those living in warehouses on stored foods, particularly wheat and flour, since the texture and moisture content of synthetic diets are closely comparable to these products. As a group, insects differ from vertebrates in their vitamin requirements. Unlike the higher vertebrates, the great majority of insects, about whose nutrition some knowledge is available, appear to be independent of an external supply of vitamins A, C (ascorbic acid) and D (calciferol). This is true of such diverse insects as the fruit fly *Drosophila*, some beetles found in stored products, the honey bee, the cockroach and certain mosquito larvae. The needs of insects for the water-soluble B group of vitamins, however, correspond closely with those of higher vertebrates though there is still ignorance with regard to the part played by certain recently discovered components of the vitamin-B complex.

It was found that *Liposcelis granicola* can grow and reproduce on a diet consisting of starch, the protein called casein, cystine (one of the amino-acids), choline chloride, ergosterol, salts and the following vitamins: aneurin (vitamin B_1, otherwise known as thiamin), riboflavin and nicotinic acid (two of the B_2 group), pyridoxine (B_6) and calcium pantothenate. This diet was not complete, for only a small number of eggs were laid, but the insects were nevertheless able to complete their life history on this diet. It would seem likely that this booklouse does not require external supplies of carotene (provitamin A) or of vitamin C, but which of the above water-soluble vitamins are essential is unfortunately not known, as the work had to be terminated before enough experiments had been done on this aspect.

In concluding this brief account of booklice, it is perhaps well to indicate how far they are typical of the group —the *Corrodentia*, or psocids—to which they belong. Their popular name is misleading. They are not true lice, as are the bird-lice and human lice. The psocids are a relatively ancient group, allied to the "white ants" or termites. It is thought that some early nest-infesting psocids gradually assumed a parasitic mode of life and gave rise to what are now the true bird-lice. Typical psocids have four wings, but there is a repeated evolutionary tendency in

the group to reduce and finally to lose the wings. Some species have short-winged forms, others have only scale-like appendages which are atrophied wings. The second tendency reflected in the evolution of the psocids is the gradual loss of the males, and this appears to be correlated in most forms with the loss of the wings. In some species males are rare, and it would seem that although the females can be fertilised, they can also lay viable unfertilised eggs. Thus there seem to have been a number of independent evolutionary lines in the group, each dispensing with the male in the economy of the species and each showing a gradual atrophy of the wings. The end stage of these two processes is reached in *Liposcelis granicola*, which is not only wingless, but also parthenogenetic (that is the eggs can develop normally without fertilisation) and male-less.

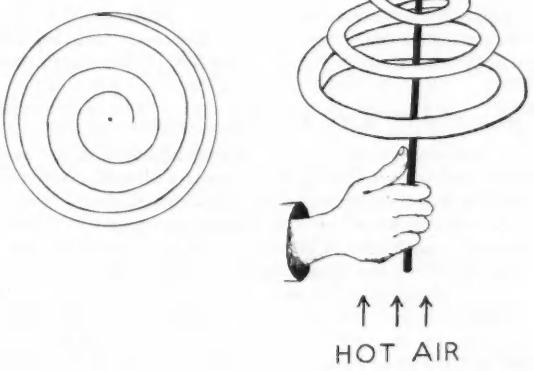
One of the most interesting facts which emerge from this is that it is among these wingless or semi-wingless and, at any rate partially, parthenogenetic forms that we find those species, which have broken away from the conservative feeding habits of the majority of members of the Corrodentia to such an extent that they have been able to find a niche for themselves in many of the artificial environments created by man.

It is hoped to continue work on various species of book-louse, and we should be very grateful if readers would send any living specimens they see to Dr. B. M. Hobby, Hope Department of Entomology, University Museum, Oxford, together with an indication of the place and circumstances of their capture.

JUNIOR SCIENCE

Heat into Work—II

Cut out from thin cardboard a circular disc of about four inches in diameter and mark the centre. Then cut a spiral line as indicated in the figure and draw the cardboard spiral out a little. Now pivot the centre on a knitting needle and hold it over a warm object such as a gas or electric cooker. Very soon the spiral will begin to turn as the hot air rising from the cooker encounters the inclined plane of the spiral and tries to push it out of the way.



Here you have a very simple machine which turns heat into work and, as I told you last time, this process of turning heat into work is the most important one of our methods of deriving power from natural resources. I also left you with a very awkward question; *When a meteor falls out of the sky and heats up on striking the earth, why does it not jump back into the sky when we heat it again?* In other words, the mechanical energy of the meteor changed into heat when the meteor was stopped; why does it not gather speed again when we apply heat energy? You may say (and this would be quite correct) that by merely heating the meteor we applied heat energy in a foolish way. Perhaps you said to yourself, we should have fed the heat into a machine and made the machine shoot the meteor back into the sky. But can you really do that? This question which worried scientists for a long time was solved a hundred years ago by the French engineer Carnot, and the answer is: NO. If you could gather up all the heat the meteor produces when it stops and put it into a machine capable of shooting the meteor into space again you can *never* succeed in sending it back to where it came from. That means you can always change mechanical work or chemical energy into heat, but you can never get the original amount of work back once the energy has been converted in the form of heat.

This is very unfortunate since, as you will remember, we always find it necessary to change the chemical energy of oil and coal into heat before using it to perform mechanical work. This means that in accordance with the law discovered by Carnot we must always squander a large amount of energy in the form of heat which cannot be turned back into any other form of energy. And this we do indeed. The efficiency, that is the amount of energy contained in fuel which can be turned into useful work, is only about 7% in a railway engine, about 20% in the steam turbines which generate electricity, 25% in an aero-engine and up to 35% in a Diesel engine of a modern liner. K.M.

Elements of European Relief

F. LE GROS CLARK, M.A.

It is not perhaps too early to attempt a scientific analysis of the course of European food relief. Our *data* may still be insufficient, and there are several regions of obscurity in the whole complex business, but objectively the picture unfolds itself somewhat in this wise. Readers will make due allowance for the rapid alteration in the relief position that was occurring even before VE-day arrived; to Holland, for instance, the flow of food by air, sea and land began at the beginning of May, and further news of relief measures will probably be released before this *Discovery* is published.

There are at present two distinct sources from which relief supplies are being drawn; that is a factor not usually recognised. The one consists of the allocations made both to the Military Command in the West and to UNRRA from the flow of food supplies at the disposal of the Combined Food Board. This Combined Food Board was established by America, Canada and Britain, at a time when these were the only countries effectively concerned. Its task is that of assessing the flow of supplies and disposing of them judiciously between the demands of the home populations, the requirements of the armed forces, the requirements for lease-lend and the needs of liberated peoples.

The other source of supplies consists of such reserves of grain as Russia can spare, together with the surplus food stocks of Rumania and Bulgaria. These supplies are doubtless far smaller than those at the disposal of the western countries. But they have their uses, and they are completely within the control of the Soviet High Command.

Phase of Military Relief

Now, it must be remembered that UNRRA is not, and never has been, conceived as a "super-national" body with right of entry to all the suffering and devastated countries. Its functions were from the first strictly limited in theory; and they are likely to be still further confined in practice. There is, for example, the military clause in the agreement. Not UNRRA but the military authorities are primarily responsible for relief, and this is where the difficulty has arisen. In the early process of liberating a country the High Command makes two requisitions on the Combined Food Board, first for food enough to feed the troops, secondly for the quantities of food it *estimates* it will need for the civilian population. Shipping and inland transport have been serious "bottlenecks" in the flow of supplies; and as a result the military authorities may at times have adopted the more optimistic estimates of civilian needs. Yet the civilians were part of our total liability, and there may have been moments when we had to decide whether it was not necessary to delay military operations by a few days in order to leave the ports and the railroads relatively free for civilian supplies.

Whether such problems have at any time arisen and been incorrectly solved, it is not possible now to judge. The truth, however, is that *behind* the Combined Food Board there lies no fully constituted supreme council of the great nations, in whose responsibility the ultimate decision would rest. No doubt in abstract some over-riding authority of this kind exists. But the actual course of events suggests that, until that authority was embodied at last in a meeting held on the shores of the Crimea, our relief policy was often confused and ill-timed. Meanwhile UNRRA could do little or nothing. It could only operate by the request of the military authorities; though its estimates might be more realistic than those of the military, it was after all no more than one of five or six different claimants all submitting their requisitions to the Combined Board upon a single flow of food supplies. It had no reserves of its own, save certain quantities of food upon which it had a right to draw.

UNRRA and the Liberated Governments

The second restriction upon UNRRA is that it can only operate in a liberated country by the request and on the terms of the properly constituted government. If a government wishes to purchase its own food supplies from the Combined Board, it is at liberty to do so; in fact the three western European countries have all decided on this course. UNRRA is, however, left with an important role. If France or Belgium submit an estimate of needs to the Combined Board, that estimate must be at the same time submitted to UNRRA for its comments; in order to protect the interests of the poorer Balkan countries, who are *not* in a position to purchase their own supplies, UNRRA can in effect cut down the estimates made by the more prosperous governments. This may not seem a very significant part to play, but it is necessary that someone should play it. UNRRA, in brief, is the ultimate authority that balances the needs of each liberated country against available supplies.

But there is a further problem, that converts UNRRA even more into a middleman or broker. It is the problem of supervising the distribution of relief to a community. The governments of Yugoslavia and Czechoslovakia have applied to UNRRA for relief and their request has, of course, been granted. Both governments feel themselves quite capable of controlling the distribution of the food among their populations and prefer that it should not be undertaken by the agents of an external authority. This question of distributing relief at one time created a dilemma which was for a while a very real one. Certain circles in this country and in the States were impressed with the notion that Poland and Yugoslavia were divided into factions, any of which would discriminate against its rivals in the rationing out of food. The Yugoslavs and Poles (at all events those on the spot) had a sense of their sovereign rights and a vague impression that there had been occasions in the past when relief workers were at times found in communication with the secret service of their own countries. A compromise has finally been reached. UNRRA is to have its agents in the Balkans and in Poland. But they will presumably be little more than *liaison* officers, and one may suspect that the real reason for their presence is the desire of the Anglo-American

authorities to protect themselves against probing inquiries in the Senate or the House of Commons.

The effect of all this has been to retard rather than ultimately to restrict the flow of food from the west. But the movement of food from the east into Poland, Yugoslavia and Hungary has had a wholesome accelerating influence on events. The Russians have apparently got down to the business without asking too many questions. If we can judge from our information, they have concentrated mainly upon relief to the large towns, where the need was of course most extreme and where the social doubts about Soviet intentions were more deeply rooted. Some 60,000 tons of grain and other foodstuffs were consigned to the eastern areas of Yugoslavia at the turn of the year; of this about 17,000 tons was allocated to Belgrade. Somewhat later we hear of a further consignment of at least 60,000 tons of grain to Warsaw and other Polish centres, while quantities of food were at the same time shipped to the liberated territory of Slovakia. A more recent estimate reports a delivery of 18,000 tons of grain and 5,000 tons of meat and other foods to Budapest. Doubtless there have been other movements of relief stores of which we have no record.

The partial fusion of the two modes of relief has helped to clean up the western schemes and mature them more realistically for their task. Now that the formalities of distribution have been more or less agreed, the problem is that of expediting food deliveries from the west. The food reserves at our disposal are, of course, limited (except for grain and perhaps coffee), and no one would care to predict the full extent of the future demand. But since some attempt is made to adjust the estimates of different countries to the actual need existing, there will presumably be a certain measure of fairness in the division of supplies. It does not greatly matter whether a country puts in its own requisitions or submits them through UNRRA. If it submits them through UNRRA, it will pay what it can out of the proceeds of any sales that may result.

Britain's Position

The effect upon our own food supplies from overseas cannot be precisely known at present. But the position seems broadly to be this. We have of course certain sources of food supply at our disposal, that lie quite outside the North American Continent; we have secured some control over exportable cocoa and vegetable oils from West Africa, dried fruits from Turkey, citrus fruits from Palestine and so forth. But here we are limited by the available shipping. As far as Washington is concerned, this country has necessarily a priority claim on food, as being, like the States, one of the great war arsenals and as being moreover the main basis for military operations on the Continent. Our own argument is primarily a social and political one. We might in theory be able to restrict our rationing of meat, sugar and fats. But are we certain that, if we did so, it would not lead to a social discomfort so great as to threaten our efficiency as an arsenal? That no doubt is a matter of leadership; Washington is itself well aware of the difficulties of rationing and food control in its own vast territory, and it is likely to be impressed by the British point of view. The Ministry of Food has argued for British priorities throughout the war, and there are no signs that it is relaxing its efforts at the present stage.

So much for a scientific appreciation of the various factors at work in deciding the form and substance of food relief. Internally on the Continent the main problem has been and is likely to be that of transport. The destruction of railways, bridges and rolling stock in all the countries has been on a huge scale. In Yugoslavia, for example, the Germans are reported to have removed almost all the locomotives, and there are practically no lorries save such as can be imported. A surplus of grain in the interior cannot readily be shipped to the coastal belt; indication of the great transport difficulties was the fact that for some period, coal could not be carried to Belgrade even from the near-by mining areas. In France and Belgium again the loss of locomotives and rolling stock from the effect of bombing was reported to have reached 70%.

This failure in transport is likely to affect also the preparation in the liberated countries for the next harvest. Seed potatoes and seed beet had normally been transported into parts of France and Belgium from Holland and Germany; unless steps have been taken to secure adequate supplies, there may be a shortage, that will affect further the provision of feeding-stuffs for the livestock. The loss of livestock in several areas is on a high level. It is especially marked in Yugoslavia; in France there is a serious shortage in horses and a loss of cattle somewhat less severe. Any importation of fresh stock, even if the shipping situation permitted it, is at present impracticable through the scarcity of feed.

Insofar as these problems can be solved, the task is that of expediting the flow of supplies. Czechoslovakia has concluded agreements both with the Soviet authorities and with UNRRA; and it is reported at the time of writing that supplies have been made ready both in the States and in Britain. Clearance of these supplies has been organised through the Black Sea ports; presumably the same channel will be used for supplies from the west to Poland. In the case of Poland both the governments have concluded agreements with UNRRA, but up to date no mission from the west has reached Warsaw, while no announcement has been made as to the extent of likely relief. Some of the rural areas of the country were less subject to devastation than had been anticipated and a few of the industrial centres are able to resume a limited production. But the condition of several of the towns is, of course, still serious, and according to Soviet information it has been necessary to rely for a time mainly on soup kitchens for the feeding of the population.

Much depends upon the state of the coming harvest, and this again depends on the supply of fertilisers and farm transport and equipment.

Of the position in the Netherlands nothing has been said. For one thing it must be still a matter of surmise, though it might be possible to give an estimate; by the time this article is published, we may, however, have all the information we need. The country will clearly be in no position to feed itself in the current year. But on the assumption that over a great part of Europe the peasantry will at least be able to supply their own requirements, the problem is how far they can also produce the excess needed for the extensive urban and industrial centres that are a feature of a civilised continent. It is these that are unable to adapt themselves however feebly to the appalling consequences of total war.

Machinery in Mathematics

AN HISTORICAL SURVEY OF CALCULATING MACHINES

S. LILLEY, Ph.D.

BEFORE 1640, nobody appears to have thought of applying machinery to the problems of mathematics. Within the next century the thought occurred to many, often independently of previous proposals, and the development of a now very important branch of technique was well under way. There are not many examples of a scientific development having so abrupt a beginning.

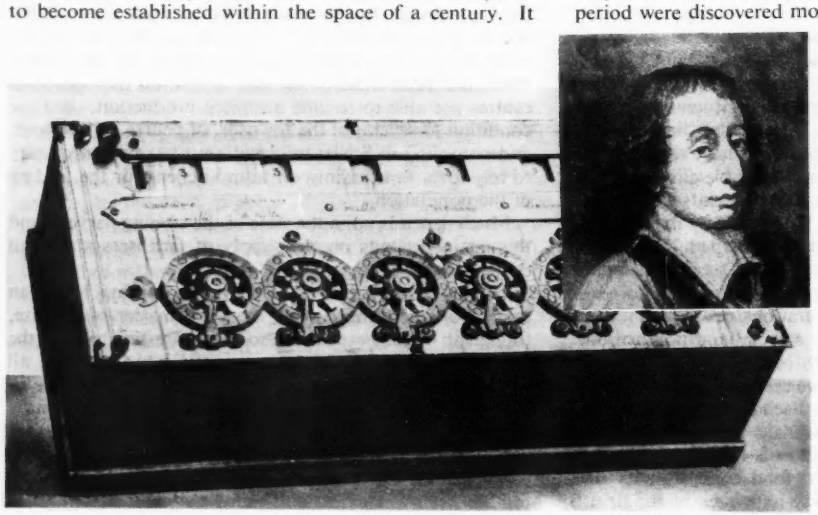
Yet the reasons in this instance are not hard to trace. Before the first attempts could be made to substitute a machine for the mind of the computer or for his abacus, three pre-conditions were necessary—a heavy demand for calculation, considerable mechanical experience, and a considerable development of physical science (the last, because the invention is not one that could be made from merely empirical approach).

These three conditions were satisfied together for the first time in the early 17th century. The Greeks had had some physical science and quite considerable demands for computation, which had led to notable advances in arithmetical methods. But their machinery was most elementary. The Middle Ages developed machinery of considerable complication, including the clock, which may be regarded as a precursor in the line of evolution of calculating machines, being after all an apparatus for counting and reducing to convenient units the number of repetitions of a mechanical cycle. But the systematic science of that period was poor and the need for computation small.

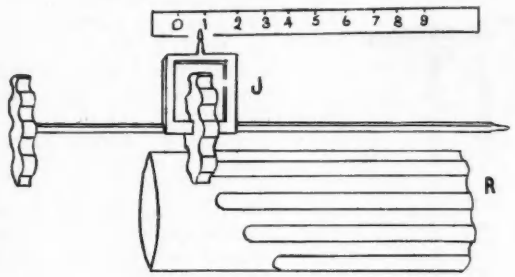
But from the mid-16th century, commerce expanded at a revolutionary speed, giving rise to unprecendented demands for calculation. Physical science as we know it to-day was to become established within the space of a century. It rose in close relation with the commercial and industrial expansion of the times. The needs of navigation, for example, played a considerable part in the growth of astronomy—and that astronomy added much to the burden of calculation. The rise of decimal fractions in the late 16th century and the invention of logarithms in 1614 were but symptoms of the growing arithmetical needs. Thus by the early 17th century all the pre-conditions for the invention of a calculating machine were for the first time satisfied simultaneously. It could not be long before the attention of some genius with sufficient scientific training and mechanical knowledge would be called to the need for a mechanical method of computation.

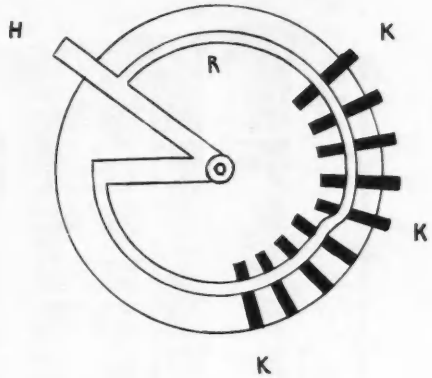
The particular genius who was first placed in that position was Blaise Pascal. His father, as superintendent of the government of a French department, Haute-Normandie, had to check an enormous number of accounts and it was to aid his father that the eighteen-year old Pascal designed his machine for adding and subtracting and constructed it with the aid of a Rouen locksmith in 1642.

These busy times of the 17th and 18th centuries, with their headlong advances in both commerce and science, gave plenty of incentive for the invention of calculating machines. At least a dozen machines had been invented by the end of the 18th century, many of whose inventors worked in ignorance of previous and contemporary efforts. The first machine with which it was posssible to multiply and divide, as well as to add and subtract, was that of Leibnitz (1694). But unless one is interested in technical points, there is little to be gained by going into detail, for only two conclusions would emerge. First, that in this period were discovered most (though not all) of the principles of a modern general-purpose machine capable of adding, subtracting, multiplying and dividing. And second that none of these machines would work. Or, to be accurate, they would work about as well as a discharge tube in the "string-and-sealing-wax" days of the Cavendish Laboratory. The technical difficulties were too great; friction could not be sufficiently reduced; gear-wheels, accurate enough and at the same time strong enough to stand the colossal wear and tear, could not be cut, and so on. The machines would work only in the hands of an expert, using them with care and able to repair the inevitable breakdowns. But in the hands of the man who wanted merely to *use* the



FIGS. 1 and 2.—The first calculating machine, and its inventor, Blaise Pascal (1623-62). The illustration of the machine is taken from Professor A. Wolf's *History of Science, Technology and Philosophy in the 16th and 17th Centuries.*





FIGS. 3 and 4.—Two common mechanisms for performing the elementary operation in a calculating machine. The counting wheel has ten teeth, so that the operation of adding 1 is equivalent to turning this wheel through one-tenth of a revolution, adding 2 to turning through two-tenths of a revolution, and so on. The number to be added is applied to another wheel in such a way that when it revolves once, then one, two, etc., of its teeth engage the teeth of the counter and turn it through one-tenth, two-tenths, etc., revolutions. Two ways of doing this are shown. In the "stepped reckoner" (*left*) the pointer is set against the number to be added on the scale above and thus the wheel J engages with the appropriate number of teeth of the wheel R. Stepped reckoners may be seen in the middle of Thomas's calculating machine illustrated on p. 153. In the "pin-wheel" (*right*) the actual number of teeth is varied. The cam-like ring R (worked by the lever H) passes through slots in the rods K; according to the position of H, the appropriate number of teeth is made to project and engage the counter, the rest remaining flush with the circumference. This mechanism is used, for example, in the Brunsviga (see p. 156).

The foregoing applies to a single digit; a complete machine consist of several such mechanisms side by side, together with devices for "carrying". Subtraction is merely reverse addition. Multiplication (on the majority of machines) is done by repeated addition, and division by repeated subtraction.

machine—and he is the really important person—they were useless.

Thus the *practicable* calculating machine had to wait until the Industrial Revolution, with its technical problems in many and more important types of machinery, had urged inventors to devise the techniques which were essential to overcome these difficulties. The Industrial Revolution gave a great impulse to the improvement of calculating machines, not only by providing the necessary technique, but also by increasing enormously the need for convenient methods of calculation, both for the accounting of the much larger businesses which arose and for the mathematical side of the scientific and technical problems which the Industrial Revolution produced.

But here we come to a curious historical circumstance, which brought it to pass that the early practicable calculating machines were developed, not in England, leader of the Industrial Revolution, but in France, the comparative late-comer—in France at the time of her industrial revolution.

The circumstance was this. English science had grown most rapidly in the 17th century, in association with the class of merchants and small industrialists who had acquired the dominant influence in English life after the Revolution of 1649 and the subsequent Restoration. Science had helped these people by solving many of the technical problems of their new methods of production. And these merchants and small industrialists, when they came to dominate England, had responded by putting science on the official map, especially in the Royal Society and at Cambridge, centres which soon came to be practically synonomous with science.

But the Industrial Revolution, based on *large-scale* manufacture with power-driven machinery, was carried through by an essentially (though not entirely) different class of men, with whom the Royal Society and Cambridge scientists had no associations. These established centres carried on with the old type of science—broadly speaking Newtonian science—partly from tradition, partly from their association with the petty industrial and mercantile classes.

Meanwhile science of the new types required by the Industrial Revolution was developed outside the old centres of learning and in the new centres of industry. It was in the hands of men like Priestly, Erasmus Darwin, Watt, Boulton and Wedgewood in the Lunar Society at Birmingham, Black at Edinburgh, Davy at Bristol, later Joule at Manchester and so on—men who were by no means always directly concerned with industrial problems, but whose researches were nevertheless influenced by the atmosphere of industrial progress in which they lived and by close personal association with industrialists.

In the early nineteenth century this new industrial science began to make an attack on the established centres. The Royal Institution was founded in London in 1799. Davy came to be President of the Royal Society. But it was not till many years later that the new type of science became really established in the old seats of learning like

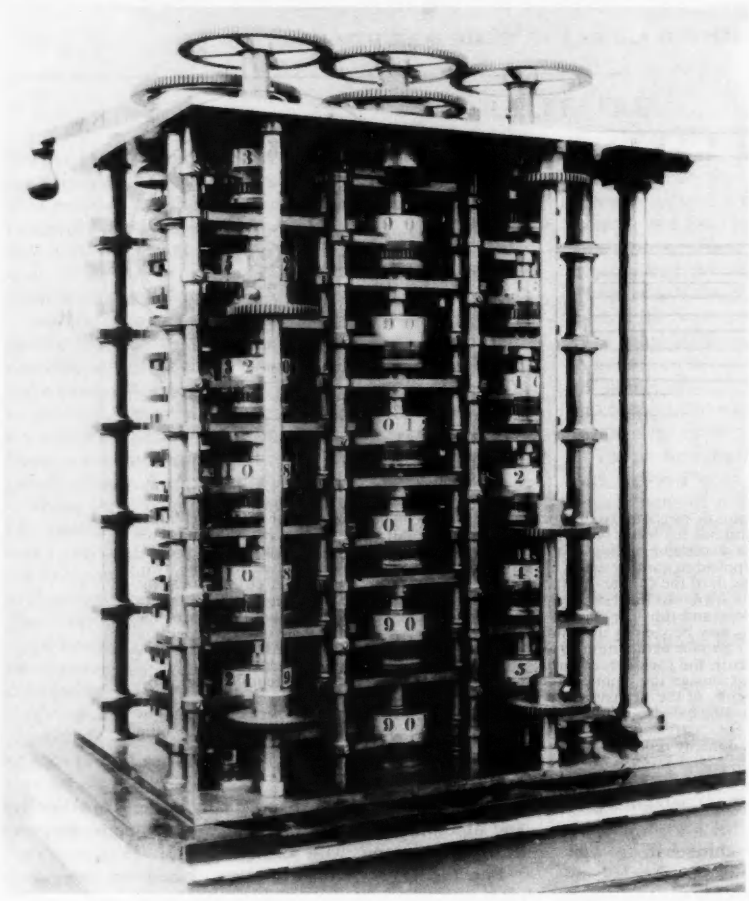


FIG. 5.—A part of Babbage's difference machine. Invented in 1812 for the purpose of calculating and printing mathematical tables, its construction was commenced in 1823; the work was suspended in 1833 and nine years later the British Government, which had financed the project, decided to abandon it on the ground of the expense of completing it. It had by then cost £17,000. (*Crown copyright. From the exhibit in the Science Museum, London*).

Cambridge and the Royal Society. And meanwhile in the early 19th century there was a great coolness, even an antagonism, between the old Newtonian science, well-established in the old centres, and the new science, the really progressive science, which was struggling for recognition.

Now Cambridge and the Royal Society were undoubtedly the seats of *mathematical* knowledge and skill. And so it came about that on the one hand the excellent mathematical ability of Cambridge and the Royal Society was out of touch with the new needs of industry and industrial science, and on the other hand the leaders of the new industrial science greatly distrusted mathematics, since it appeared to them to be merely a part of the old conservative science. English mathematics and the English industrial revolution were split poles apart with the result that in general English mathematics dropped far behind that of the continent and in particular the step of producing a practicable calculating machine, which depended on a close relation between mathematics and the Industrial Revolution, was not taken in England.

In the second decade of the 19th century a few bright spirits had begun to reform Cambridge mathematics. Their immediate struggle was to replace the old Newtonian fluxions by the methods of *analysis* based on Leibnitz's calculus, which had developed on the continent and had taken continental, especially French, mathematics far ahead. Behind that immediate struggle one can trace a background, not consciously realised by most of the reformers. Newtonian and Leibnitzian methods were almost equally suitable for the problems of the earlier science, concerned with astronomical and simple mechanics. But for the problems of the 19th century, problems related in various degrees to the growth of large-scale industry, analysis was far superior. In fact, though seldom in personal motive, the reformers were calling for a mathematics suited to the industrial revolution. In France, mathematics was by no means tied to industry, but the relations of the two were considerably closer; and this was one of the factors in the very rapid progress of French mathematics at this period.

The success of the Analytical Society in introducing the new mathematical methods did not, however, mean that Cambridge science immediately became united with industrial progress. That did not come about for another half century. Indeed, it is doubtful if many of the men concerned in the battle could even see that such was to be its ultimate result. They were influenced by the social question only in very indirect ways, chiefly by seeing the success of analytical methods in France, but they did not realise at all the connection between that success and industrial progress. But at least one of them went some considerable way towards understanding the issues. That man was Charles Babbage, later Lucasian Professor of Mathematics at Cambridge.

If ever there was a genius, a pure, erratic, uncontrolled genius, Charles Babbage was one. His mind was capable of the most brilliant flights of imagination and his judgment was utterly incapable of tempering that imagination to suit the practical material world that surrounded him. His brilliance broke right through the traditions of his day. He stood in the front line of the attack on the decadence

of the Royal Society, which few men of his position could even see, to say nothing of gathering enough energy and initiative to attack it. He wrote a fighting pamphlet in 1830 on *The Decline of Science in England*. He saw, at least partially, the importance of the Industrial Revolution and wrote a treatise in 1832 on *The Economy of Machines and Manufactures*. He did not, of course, see the whole undustrial, economic and scientific struggle as an integrated whole, but he saw much more than could have been expected from a Cambridge don of those times.

It is not surprising that it should have been such a man who tried to make a useful calculating machine in England and it is equally not surprising that his attempt should have been Utopian in the extreme.

He was not content with taking the next step and moulding one of the earlier types of calculating machines into practicable form with the aid of the new techniques. Instead he wished to produce a machine, called a "difference engine", for building up tables of functions from their differences, using addition and subtraction only—an enormously useful kind of machine, as we know to-day, but also so enormously complicated that it was certainly not the next step to be taken at a time when no practicable calculating machine had yet been produced. He got the government to undertake its construction in 1823, but the work was suspended in 1833, when already £17,000 had been spent on it, and it was finally abandoned in 1842.

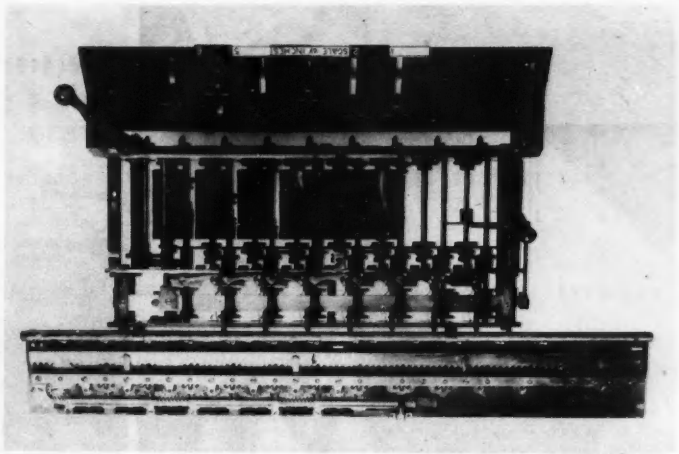


FIG. 7.—An almost exact replica of the Thomas de Colmar Arithmometer. To show the internal construction the figure plate has been removed and inverted; the slide is also turned back. This machine was produced by Arthur Burkhardt of Glashutte, the first maker in Germany to manufacture this type of machine. This particular instrument was probably made in 1880. (*Crown copyright*)

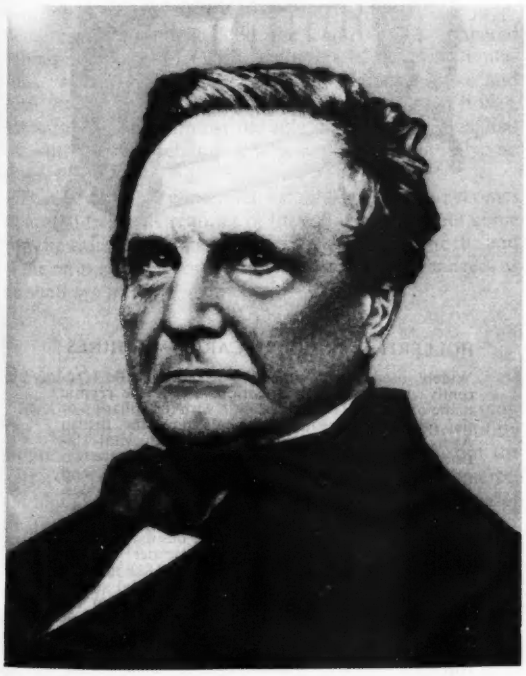
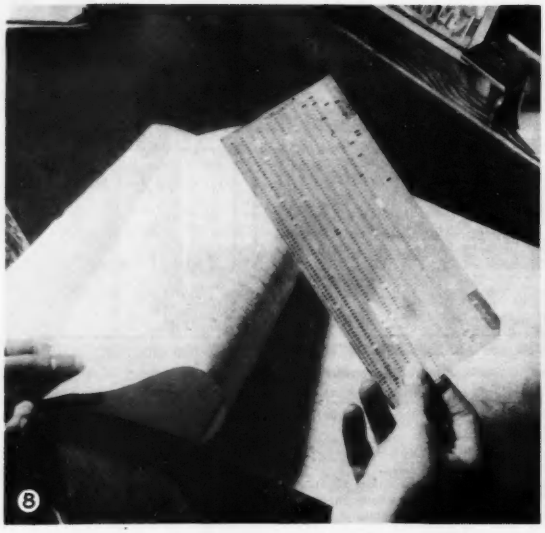


FIG. 6.—Charles Babbage (1792-1871).

One reason for the failure and for the enormous cost lay in the technical difficulties, but it is probable that technical advance in other fields had by then gone so far that these could have been overcome, provided the problem had been attacked step by step by constructing simpler machines and making them work before starting this giant venture. But Babbage's imagination could not be restrained in that way. He went for the best conceivable; he had no use for the best practicable. His ill-controlled genius played him false, too, in that it suggested improvements and revisions of his plans so frequently that the work could never make any real progress.

Roth, a Frenchman who played a notable though modest part in the development of calculating machines in his own country wrote: *Since the month of October* 1834, *Mr. Babbage has occupied himself incessantly in perfecting the plans of his machine . . . I saw last year* (1841) *the thirtieth plan . . .: if ever it is constructed, which is doubtful, since it will cost at least another* £20,000, *it will be a chef-d'œuvre of human conceptions.* Roth thought it impossible, or at least very improbable, and Roth ought to have known, since he was living in a country which gave every encouragement to the inventors of calculating machines, but at the same time strongly insisted that they should be constructable, not merely conceivable.

It was, in fact, a consequence of the split between established science and progressive industry that only a very great genius could overcome the division and unite the trends which must come together before a calculating machine of practical importance could be produced. And a genius of that calibre is as likely as not to be unstable



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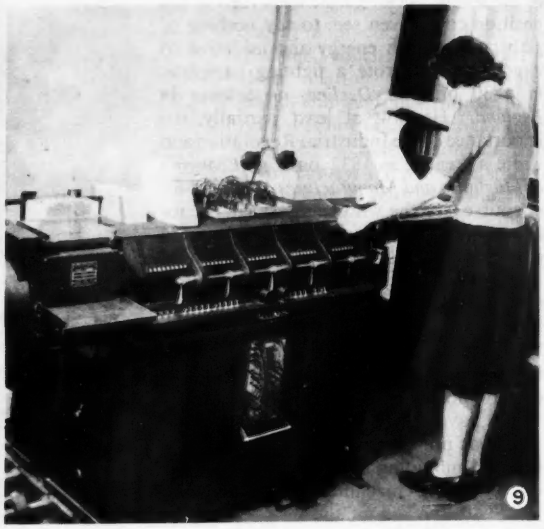

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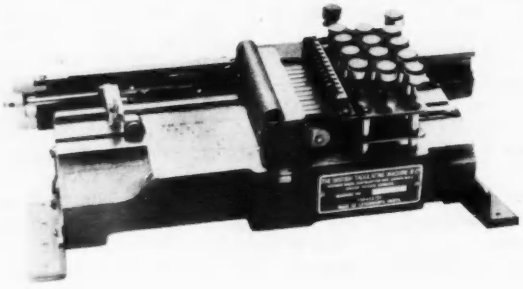

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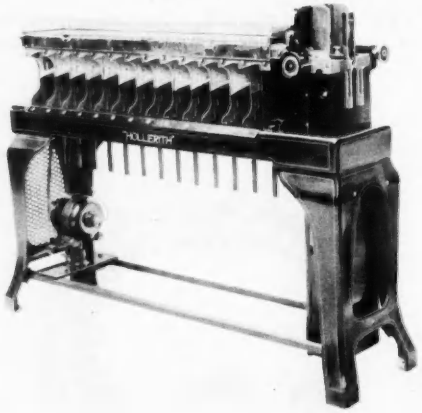

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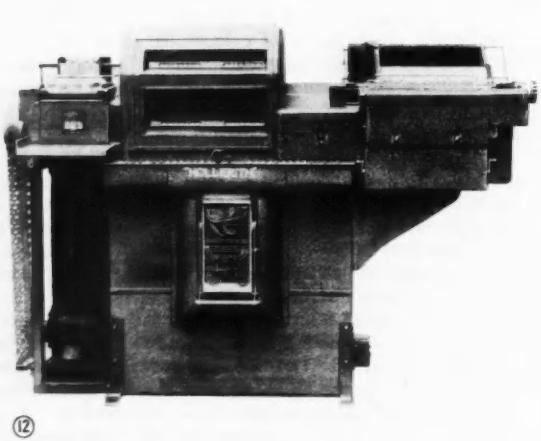

(12)

HOLLERITH PUNCHED-CARD MACHINES.

Widely used for commercial accounting, they recently attracted public attention—under the cryptic name of WOCCI—in connection with the collation of the information required for planning the British Army's demobilisation. The analysis of vital statistics and the data obtained by social surveys are two other fields of application. Fig. 10. Figures, and facts translated into figures by use of numerical codes, are first punched on to cards by this machine (*see* Figs. 8 and 13). Fig. 11. By means of this machine the punched cards are sorted into any desired sequence at a speed of 24,000 cards per hour per column. Figs. 9 and 12. Finally the cards are fed through the tabulator to produce analyses. In social survey work, for instance, the tabulator can total up the number of people who have given the same answers to particular questions, and select the answers of men only or women only or of any particular group required.

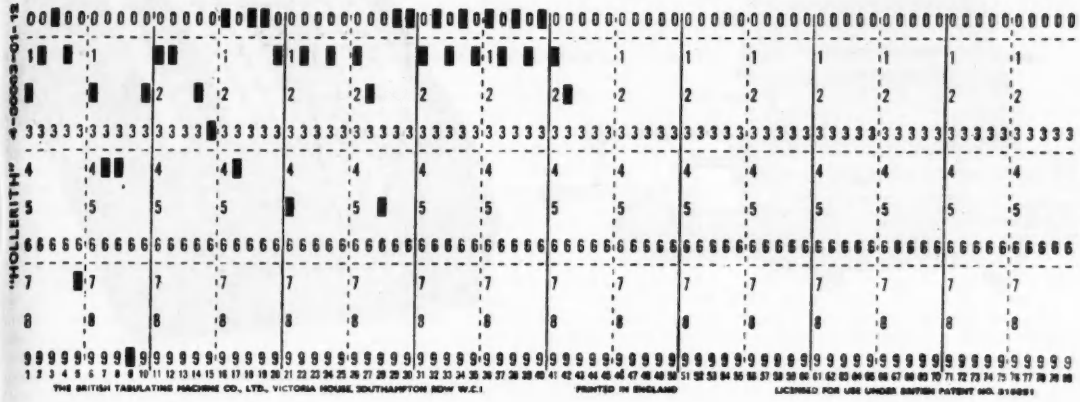

FIG. 13.—A Hollerith punch card. This particular one carries a set of answers obtained in a study of household lighting made by Wartime Social Survey; the results were recently published in the *Post-War Building Studies* series. Theoretically it would be possible, since there are 80 vertical columns and 10 horizontal ones, to record 800 facts on a card; for social survey work 80 facts per card is an average figure. On the punched portion of this card 23 facts are registered. In a form ready for mechanical analysis the following facts about the person interviewed and the lighting in her home have been set down; she is a London flat-dweller, lives alone, earns £187—260 a year, pays 6½—8½d. a unit for electricity; her kitchenette has light-coloured walls, a single electric lamp hanging from a white ceiling; over the sink, cooker, and table the illumination is 1 foot candle; before the war she used 60 watt lamps.

and of uncontrolled imagination. In a society in which industry and mathematics were more closely linked, other men, less gifted in imagination, but more sober in judgment, could have provided the control and tempered Babbage's conception with reminders of material limitations, much in the same way that Halley, Hooke and Wren had earlier guided the steps of Newton. As it was, Babbage remained almost the sole link and there resulted his wild and ever-changing schemes and, eventually, no progress.

That is what happens when established science becomes separated from the realities of life. England did not come into the calculating machine picture again till near the end of the century when conditions were very much changed, as we shall see in a few moments.

Developments Abroad

Meanwhile in France the situation was very different. The clear break with feudalism in the French Revolution produced a social system in which science was from the start associated with the whole of industry and commerce, not merely with parts of it as in England. The freeing of creative energy after the Revolution, and especially after the peace of 1815, produced a great upsurge of social, economic, technical and scientific advance, all closely integrated together. Typical of the times was the *Société d'Encouragement pour l'Industrie Nationale*, founded in 1801, publishing papers on a wide range of subjects, economic, technical and scientific, welding these together and considering their inter-relations.

The general social conditions in France at this period were ripe for bringing together industrial technique and mathematics to give birth to a really useful calculating machine; and the *Société d'Encouragement* acted as a very efficient midwife by encouraging inventors and reporting on their inventions with reference, not merely to their technical content, but also to their social and industrial applications. It was to this body that Thomas de Colmar went for help and encouragement when he produced a workable calculating machine in 1820. The society reported favourably on his machine and gave considerable publicity to him and to several other French inventors who successively improved it.

I cannot here describe the gradual perfecting of the Thomas machine as carried out by Thomas and his successors. I can only mention one important step. Up till 1841 machines had been so arranged that all the carry-overs from one figure to the next occurred simultaneously. That meant a great strain on the machine (and the computer) when performing such an operation as 999,999 + 1 = 1,000,000, where six carry-overs occur together. In 1841, Roth, whose comments on Babbage I have already mentioned, produced a machine in which the carry-over was staggered from each digit to the next—in "*feu de file*", as he put it, as opposed to "*feu de peloton*". His machine was for adding and subtracting only, but his innovation was soon incorporated in the general run of calculating machines.

The Thomas machine rapidly achieved popularity after its initial difficult years. From 1821-65 annual sales averaged only eleven machines and these were of many models as improvements were rapidly introduced. From 1865-70 the annual average was 60. From 1870-75 it was 80, and in the three years 1875-8 it was 100.

It was in 1878 that Odhner produced his machine, based on a different principle (pin-wheel instead of stepped-wheel)

FIG. 14.—A Brunsviga calculating machine.

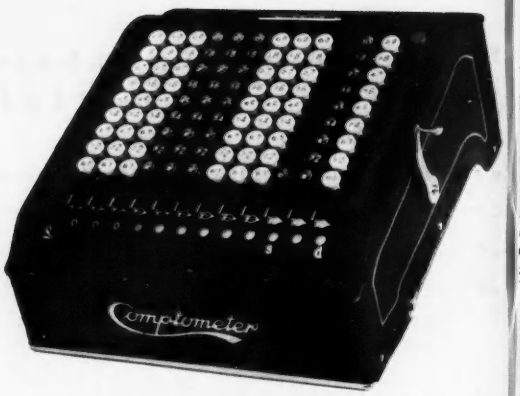

FIG. 15.—A Comptometer machine.

which, however, had been anticipated (with the usual inability to put it into practice) by Poleni in 1709. The Odhner type of machine proved to be an enormous success. The German Brunsviga, and the Odhner type, appeared in 1892 and 20,000 of these machines were made within twenty years.

From that time on, progress has been very rapid and the tendency has been towards keyboard-operated, electrically-driven machines, though the hand-operated machine is still by no means out of date. The first keyboard machine was that of Schilt in 1851. The first commercially produced ones were the Comptometer, 1887, and the Burroughs adding machine, 1888.

Before passing on to the much more general types of modern times, let us note some developments which started with Babbage's difference engine. Such machines are inflexible and of little use for the majority of computations, but in the preparation of mathematical tables, a very important job, they are almost indispensable. They were largely impracticable in Babbage's time, quite apart from Babbage's own unpractical attitude, but after a few years' experience on simpler machines like that of Thomas they became quite practicable—after all they are nothing more than a number of adding machines suitably coupled together. The first successful difference engine was conceived by Scheutz, a Swede, in 1834, but not actually constructed till 1853. It used only four orders of differences and its use was therefore severely limited. Other and better difference engines were produced by the Swede Wibebg and the American Grant in 1871. And now this type of machine is thoroughly familiar in the form of the "National" which plays a great part, for example, in the preparation of the Nautical Almanac.

But Babbage had another and even more ambitious idea which has not so far been mentioned—his "analytical engine" (1833), which was to perform automatically by punch-card methods any given sequence of computations. Such a machine has never been constructed, but many of its functions can be reproduced by the set of Hollerith punch-card machines, which have also got uses beyond the scope of the analytical engine.

[To be concluded

Science and the Citizen

THIS item devoted to scientific films and radio programmes seems an appropriate place in which to refer to the work of the late Mr. Percy Smith, the photographer who broke new ground with his *Secrets of Nature* and *Secrets of Life* films which are to be ranked among the finest educational pictures made in Britain. Mr. Smith's death on March 24 represents the loss of a unique character from this branch of cinematography: he combined the acute observation of a first-class naturalist with a great ability for visualising biological phenomena, in particular developmental processes, as a fluent sequence on a cinema screen. To capture on celluloid the growth of a dodder seedling, the opening of a flower, the emergence of a dragonfly, called for the use of what is now eruditely called "time-lapse cinematography" or accelerated motion photography. The filming of moving microscopic organisms added a further set of problems to the work. There was no apparatus on the market to do the jobs which Mr. Smith wanted to accomplish, but he overcame his difficulties with a mechanical ingenuity that would have done Heath Robinson credit—there were indeed times when he knocked together contrivances that looked remarkably like something out of a Heath Robinson sketch. Crude though they may have been they were extremely effective, and he was able to transfer to the screens of city cinemas biological studies that gave audiences an education in natural history that in some respects it would have been hard for a naturalist spending his life in the country to gain. Much of the knowledge so presented was also beyond the range of the laboratory biologist.

An entertaining description of how these films were made is provided in the book which Percy Smith and Mary Field wrote under the title *Secrets of Nature*; this book is illustrated with stills from the films, and another set of such stills is to be found in the Pelican book *Cine-Biology*, which was designed as a popular textbook to supplement the films which Percy Smith and Mary Field made about invertebrate animals. The greatest tribute that could be paid to Percy Smith's memory would be the perpetuation of a film unit capable of retaining the lead that the Gaumont-British Instructional team, and Percy Smith in particular, gained for Britain in this particular branch of film production.

The Bookshelf

Medicine and Mankind. By ARNOLD SORSBY. (London, Watts, Thinkers' Library (Science Section); x + 116 pp. GOOD health is the reflection of an extremely delicate state of balance and is not to be taken for granted; disease (an apt word) is strictly the more normal condition and is a disturbance of this equilibrium. This is the central thesis around which this little book is written. The author deals in turn with the factors whose equilibrium is Health, with the variety of ways in which this balance may be upset, with Therapeutics (measures which assist the individual to restore his bodily balance) and with collective measures for the prevention of widespread disease. Into the background of these chapters Dr. Sorsby contrives to weave a sufficient amount of medical history for the reader to view the field in perspective. The summing-up is just and impartial, acknowledging many instances where much effort has been rewarded with little real progress. In his final chapter the author looks into the future but deals with the probable advances in medical science rather than with the organisation of medical services.

As his dedication of the book reveals, Dr. Sorsby regards doctoring as a vocation rather than as a profession and, in the light of his enthusiasm, the other side of the coin (which we were allowed to see in such books as *Arrowsmith*, *The Citadel* and *Dr. Bradley Remembers*) is cast into shadow. Dr. Sorsby tells his story clearly and well, striving always to find arresting phrases with which to leaven his facts. Sometimes this practice has a happy outcome—as in the statement that "asepsis . . . is not an exercise in quixotic millinery"—but on another occasion he lets his pen slide into the statement that "the jungle (of primitive pharmacy) had been cleared, but it became a blossoming plain only after the tidal wave of bacteriology had broken over it". And, again, this boldness in the perilous ways of Metaphor leads him to refer to "homœopathic bogs" and to "the arid winds of homœopathy" in the same sentence!

A short glossary and index are provided at the end of the book. When so large a subject is compressed into so small a volume, a glossary tends either to be inadequate or superfluous; it would perhaps have been better had the author extended his practice of defining technical terms in brackets as they occurred in the text. R. P. HILL.

The Elements Rage. By FRANK W. LANE. (London, Country Life, 1945; pp. 188; 10*s.* 6*d.*).

Weather Around the World. By IVAN RAY TANNEHILL. (Princeton University Press, 1944; Humphrey Milford, O.U.P.; pp. 200; 16*s.* 6*d.*).

RARELY has the reviewer met two more fascinating books, or found so much entertainment in contrasting the styles of the two authors. Mr. Lane has an appetite for meteorological and volcanic catastrophe, and whether it be that we take a ghoulish delight in the terrific and sometimes freakish destruction which can be wrought by typhoon, tornado, hurricane and earthquake, or whether it is the verve and swing of Mr. Lane's style, it is extremely difficult to take time off for meals until the book is finished. One gains the impression that here and there Mr. Lane is a bit happy-go-lucky with his numbers, but he has taken the precaution of having the book read in manuscript by eminent authorities, so that there cannot be much wrong. Anyway, who cares for the niceties of expression with a book like this. It is not a textbook and was not intended to be, and I for one enjoyed it more than many a detective story. It contains any amount of information, some of it sober, and some of it entertaining, like the story of the man who was carried up by a tornado and found that he was hanging on to the tail of a horse. Without wishing in any way to diminish the praise which Mr. Lane so richly deserves for his written text, let me say that the best part of his book is the superb collection of photographs. The reason why this implies no criticism of Mr. Lane's text is that they are quite the best collection I have seen in any book of its kind. Some of them, such as those of ball lightning, of a fireball which passed over the United States, of the destruction wrought by the great Siberian meteorite, and particularly those of tornadoes, are superb pieces of scientific recording; there is not a dull photograph in the book. There is nothing for it; if you really want to appreciate this book you had better queue up at once to buy it.

Mr. Tannehill's book is equally good but in a different way. He writes for the American likely to be sent almost anywhere in the world on war service, and he has produced a very handy little reference volume which will be a mine of information for those who want a piece of climatic information without having to search a library. It is what it claims to be: a description of weather round the world, with all the charts, tables and maps one could wish for. But Mr. Tannehill too has photographs, which perhaps are not so spectacular as Mr. Lane's, but nevertheless score top marks for excellence. The remarkable thing is that there is practically no overlapping between the two books in this respect, so that it is not a case when the reviewer has to suggest a decision between two alternatives, but is able honestly to recommend that both should be bought. DAVID S. EVANS.

Greek Science, Its Meaning for Us. By BENJAMIN FARRINGTON. (London, Pelican Books, 1944; pp. xi + 143; 9d.). PELICAN BOOKS are almost always both readable and edifying. Occasionally—and this usually occurs when the book is specially written for the series—they go farther and are positively stimulating. Professor Farrington's *was* specially written and *is* one of the most stimulating books on the history of science in recent years. It is not a mere account of Greek science. As its sub-title indicates, it is a critical attempt to draw positive lessons from this part of history.

Its main theme, crudely stated, is an investigation of the relations of Greek science with the technical, social and political developments in which it grew. But the theme is *not* crudely stated in the book. It is developed with a wealth of variety, each variation being carefully fitted to the exact circumstances of its times. It is not suggested for one moment that all the great advances arose from attempts to solve technical problems—an exaggeration that in the past has damaged the reputation of the "social" school of historians of science. Some did so arise; but in general it is merely argued that the great advances were made by men who were well acquainted with the technical attack on nature, who developed therefrom a positive, inquiring, and to some extent experimental, attitude, and who maintained that attitude when attacking the deeper philosophical problems. "It was the success with which he applied his techniques that gave the Ionian natural philosopher his confidence that he understood the workings of nature." (p. 72).

Complementary to this is the analysis of the anti-scientific trend, as typified by Plato, which eventually killed the promise of early Greek science. This is shown to arise on the one hand from the tendency to despise the techniques which arose in the later fifth century when slavery became predominant, and on the other hand from political motives akin to those that have led to the fascist distortions of science in recent times. But again the approach is not one-sided—the positive content of Platonic and similar thought, its value as a criticism of some of the naiveties of the earlier schools, is well described.

When the extreme sparsity of the evidence available (arising from the wholesale destruction of the records of early Greek thought) is taken into account, I think it will be granted that Professor Farrington has proved his case. If one criticism may be put forward, it is that the case might have been made stronger by a detailed consideration of the outstanding technical advances made in the period 600-450 and the lack of such advances between 450 and the Alexandrian conquests. The fact that the former corresponds to the period of scientific advance and the latter to anti-scientific Platonism, is almost certainly more than a coincidence.

The book ends with Aristotle. We may hope that the half-promise, conveyed in the Foreword of another volume on the Alexandrian age will be speedily fulfilled.

S. LILLEY.

LETTER TO THE EDITOR

Swings, Roundabouts and Scientists' Pay

SIR,—Attached is a piece of reportage from the *Daily Mail* of April 3, 1945, which was accompanied by pictures of The Public who had paid 1s. each to swing through the air for a minute or so—a pastime that most monkeys are still able to pursue, despite the advance of civilisation and the blessings of science, entirely free of cost and without the assistance of machinery. The enterprising promoters of this exquisite amusement made, one gathers, a very nice thing out of it and I don't blame them. Indeed, I blame no one. I merely point out some interesting contrasts between the remunerations accruing respectively to those who, in this enlightened age, invest their money in Giant Rats and Roundabouts, and those who misguidedly devote themselves to unbusinesslike and unpractical scientific studies.

And now for our British Scientists and Technicians:—

"Cadets will . . . be appointed . . . on a salary scale of £200-£20-£500 a year, plus bonus . . . Essential qualifications: (a) 1st or 2nd class honours University degree with Physics or Mathematical Physics or Mathematics as a major subject and 1st or 2nd class honours in that subject, or (b) 1st or 2nd class honours University degree in Mechanical or Electrical Engineering . . ."

So 40 minutes on the swings and roundabouts equals one year's salary for a 1st class honours graduate.

". . . High-grade technician wanted for laboratory . . . real constructive ability and initiative . . . Salary between £4 and £7 a week . . ."

160 *Looks at the Giant Rat keep a high-grade laboratory technician for a week.*

". . . Tutor . . . to teach Physiology for Final Honours School and 1st examination for the Degree of Bachelor of Medicine and to supervise work of undergraduates reading Science. The initial salary would be £300 a year . . ."

". . . an honours degree in metallurgy and some years experience in the machine or machine-tool making industry is essential. Initial salary, £400 p.a. . . ."

£300 an hour and—

EASTER Monday holiday crowds traditionally thronged Hampstead Heath yesterday, to enjoy what may be the last war-time fair. Proprietors of swings and roundabouts did an enormous trade, charging 1s. a ride for each person. At that rate, the machines were taking about £300 an hour. On the "Chairaplane," seen in the Daily Mail picture below, 48 people at a time sailed through the air for just over a minute for 1s.—£100 an hour, including change-overs. American sailor cap fashions have become popular again, as you can see in the picture on the right.

NOTE. For 6d. a look, visitors could see a gigantic rat labelled "Musso."

". . . Editorial assistant required . . . good knowledge of French and Spanish essential; familiarity with medical terminology an advantage . . . full details of qualifications and experience (including a list in chronological order of posts held) . . . salary about £350 p.a. . . ."

Wonder what they pay the chap who puts the grease on the roundabouts?

". . . Laboratory apprentice . . . 30s. per week . . ." (*Or 8 seconds on the swings and roundabouts*).

". . . Technical assistants . . . with Higher School Certificate or Inter. B.Sc. in physics and/or maths. . . . £2 10s. per week . . ."

Or, of course, 100 looks at the Giant Rat, Musso.

Well, now we know, don't we? Anybody who is fool enough to study science for a living, instead of catching Giant Rats and running roundabouts has only his own stupidity to thank if he has difficulty in raising a family decently. And, of course, he should be under no highbrow illusions as to what this war was fought (with his brains and knowledge) to preserve. W. H. CAZALY.

Far and Near

War-Time Work of D.S.I.R

IN a lecture to the Royal Society of Arts on April 18, Sir Edward Appleton gave a few details of some of the war-time investigations carried out by laboratories of the Department of Scientific and Industrial Research, of which he is secretary. He said that in collaboration with the Ministry of Home Security the Building Research Station and the Road Research Laboratory have applied their knowledge of materials, and in particular concrete, to the study of bomb damage and the design of air-raid shelters. When Britain passed from the defensive to the offensive the Road Research Laboratory played an important part by studying methods for destroying enemy buildings, and in the design of bombs for special purposes; the plan for the famous air assault on the Ruhr Dams was first worked out in models at this laboratory. At the Building Research Station the study made of the effect of enemy incendiary bombs on our buildings was adapted to the study of the effect of Allied bombs on enemy methods of construction, models of which were put up at the Building Research Station. In this sphere also the Chemical Research Laboratory carried out important work on the production of foams for fighting oil fires.

More nearly in its own field the Road Research Laboratory has made extremely valuable contributions to the design of runways for airfields, particularly for producing and rapidly laying temporary runways in forward areas. The Fuel Research Station successfully investigated methods for treating fuel for flame-throwers. The Station also produced a simple and effective means for preventing the emission of smoke by ships at sea, based on simple modification to the doors of marine boilers. This work should have important peace-time applications to land-boilers both in improving the efficiency of combustion and in preventing smoke pollution. The help of all the divisions of the National Physical Laboratory has been sought on many problems; for example, models of assault craft of all descriptions have been tested in the tanks of the ship division, including models of parts of the Mulberry Harbour.

The advice of the Water Pollution Research Laboratory was sought in the treatment of waste waters from Government factories. The laboratory also succeeded in perfecting a chemical means of converting sea water into drinking water with equipment which could be used in the rubber dinghies employed by airmen forced into the sea. The Forest Products Research Laboratory has co-operated closely with the Ministry of Aircraft Production in the study of plywood and adhesives used in the construction of wooden aircraft. On the food front reference has been made to the important part played by the department in the study of dehydration and other problems. Sir Edward also mentioned the work carried out at the Chemical Research Laboratory on the production of food yeast and its possibilities in providing cheaply and rapidly a supply of proteins enriched with vitamins for under-nourished populations.

The industrial research associations have also made important contributions of which the following are examples. The Cotton Research Association has produced a waterproof cotton cloth, the fibres in which are twisted in such a manner that they swell immediately when they come into contact with moisture and so block

up the interstices of the cloth and make it water-resistant without any other waterproofing treatment whatever. These cloths, while they are impermeable to water, allow the air to pass through them. They are now being produced by a section of the industry. A hose-pipe has been made from them which will stand up to the Home Office tests and garment cloths are being made for the clothing of airmen who may be immersed in sea water. This is an invention which should obviously have a great future after the war. The processes developed by the Wool Research Association for preventing the felting and shrinking of woollen goods have been employed by the Army for the production of under-clothes and socks for the troops with excellent results. The Laundry Research Association has advised on field laundries and the best means of washing without or with very little soap. This Association also has devised a method or treating blankets with oil which has done much to reduce cross-infection in hospital wards. The Paint Research Association has done valuable work in the improvement of camouflage paints.

Personal Notes

DR. H. A. KREBS has been appointed to the newly-created chair of biochemistry in the University of Sheffield.

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MR. A. B. WINTERBOTTOM, who joined the staff of the British Non-Ferrous Metals Research Association in July, 1943, after being repatriated from Germany, has been appointed lecturer in electrometallurgy in the University of Manchester.

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MR. C. F. HICKLING, senior naturalist on the staff of the Ministry of Agriculture and Fisheries, has been appointed Fisheries Adviser to the Colonial Office, in succession to Dr. E. S. Russell. Mr. Hickling is the first full-time occupant of this post.

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THE Longstaff Medal of the Chemical Society for 1945 has been awarded to PROFESSOR N. V. SIDGWICK, in recognition of his outstanding work as an exponent of the electronic theory of valency, and of the leadership he had given in the generalisation of relations between electronic structure and chemical properties over the whole domain of chemistry.

In presenting the Harrison Memorial Prize for 1944 to DR. LESLIE F. WIGGINS at the Society's annual meeting, the President, Professor W. N. Haworth, said the prize was awarded to a chemist of either sex who shall not be more than 30 years of age and who, during the previous five years, shall have conducted the most meritorious and promising original investigation in chemistry and published the results of such work. The prize should be regarded as an exceptional distinction to commemorate an exceptional man.

THE following awards have been made by the Geological Society: *Wollaston Medal*, PROFESSOR O. T. JONES, Emeritus Professor of Geology in the University of Cambridge; *Murchison Medal*, DR. W. CAMPBELL SMITH, Keeper of Minerals in the British Museum (Natural History); *Lyell Medal*, DR. L. F. SPATH, of the Geological Department of the British Museum; *Bigsby Medal*, PROFESSOR L. R. WAGER, of the University of Durham; *Prestwich Medal*, MR. A. S. KENNARD; *Wollaston Fund*, DR. D. R. GRANTHAM; *Murchison Fund*, DR. W. A. DEER.

MR. A. H. TAITT, of the Anglo-Iranian Oil Company, receives one moiety of the Lyell Fund for his work on the exploration for oil in Great Britain, especially in the Nottinghamshire oilfield; another moiety of this fund goes to DR. F. B. A. WELCH of the Geological Survey.

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THE death occurred on April 19 at the age of 95 of SIR AMBROSE FLEMING, inventor of the thermionic valve which revolutionised wireless telegraphy and made wireless telephony possible. He had been intimately associated with the development of all the great applications of electrical science in the last 25 years—the telephone, electric lighting and radio. Educated at University College, London, the Royal College of Chemistry and St. John's College, Cambridge, he was for a time lecturer in applied mechanics at Cambridge. While at Cambridge, where he worked under Clerk Maxwell, he investigated electromagnetic waves. In 1898 he became associated with Marconi's early demonstrations, and in the next year he designed a wireless station which was set up at Poldhu in Cornwall; from there, on December 12, 1901, he was able to transmit signals to Marconi in Newfoundland.

Among the industrial posts he held was that of scientific adviser to the Edison Electric Light Company, and he contributed much to the development of London's electric lighting system. From 1910 onwards he was professor of electrical engineering at London University. Among the numerous awards he received was the Hughes Medal of the Royal Society, to which he had been elected a fellow in 1892. He wrote many textbooks. (Readers interested in further biographical details should consult his book, *Memories of a Scientific Life*).

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MR. A. R. HINKS, F.R.S., secretary of the Royal Geographical Society since 1915 died on April 18 at the age of 71. Mr. Hinks, who became distinguished for his contributions to both astronomy and geography, started his career as assistant at the University Observatory, Cambridge, under Sir Robert Ball, being promoted chief assistant there in 1903. While at Cambridge he was responsible for reducing the observations made at nine observatories for the purpose of determining the solar parallax; this work gave results whose accuracy was only surpassed by the solar parallax determination of 1930-31 (the results from which were not complete until 1941). For this contribution to astronomical science he was awarded the Gold Medal of the Royal Astronomical Society, of which body he was secretary for the years 1909-13. For his services in the field of military map making during the 1914-18 War he received the C.B.E. in 1920.

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SIR NAPIER SHAW, the distinguished meteorologist, died on March 23 in his 92nd year. After studying at the universities of Cambridge and Berlin he was elected a fellow of Emmanuel College, Cambridge, and during the years 1887-99 he was a Cambridge lecturer in experimental physics. In 1905 he was appointed director of the Meteorological Office, a post he held until his retirement in 1920. For the following four years he occupied the chair of meteorology at the Royal College of Science. Besides a physics textbook that he wrote with Sir R. Glazebrook, he produced several standard works on meteorology.

Science Masters' A.G.M.

THE Science Masters' Association held their annual meeting in the science department of the City of London School from April 9 to 11, about 300 members attending. For his presidential address Mr. C. L. Bryant, late of Harrow School, took the theme "The Impact of Science on Human Beliefs". He suggested that the criticism levelled against Christian missionaries of uprooting the faith of the natives without replacing it with anything more suitable, could nowadays be raised against science. At the present time most people believe in nothing at all, not even in science, except as a provider of luxuries. It was the duty of science masters to give a background of philosophy to their teaching and the barriers between scientists and ecclesiastics must be broken down. Man is still an infant in the universe; it may well be that religious belief is not a vestige, but a rudiment, he commented.

The "Science and Citizenship" lecture was delivered by Mr. J. G. Crowther, his subject being "The Social Relations of Science". He said that to cope with the consequences of the impact of the new discoveries a new educational outlook is needed, and he remarked upon the absence of a "History of Science" chair in British universities. Science masters must teach the relationship of science to other human activities and should be given every encouragement and material assistance in this.

Sir Alexander Fleming lectured on penicillin, and other lecturers were Mr. C. Bibby, Mr. F. W. Cuckow, Mr. R. Maitland and Dr. J. McG. Bruckshaw.

In a discussion on "The Role of Science in the Future Educational System", Mr. A. W. Wellings, Leamington College, examined the criticisms levelled against present science teaching and suggested lines of future progress. Science must be made an adventure and the technique of teaching it so altered that pupils appreciate its effect on human activities in general. A method of doing this for chemistry was outlined, basing the study on natural resources. Mr. Marchant, Ilford County School, advocated General Science for all types of school up to

School Certificate standard, emphasising the need for a strictly scientific approach. Careful consideration must be given to the elimination of irrelevant matter and to the presentation of subjects at the stage best suited to their difficulty. Individual practical work must form an important part of the General Science course. Other speakers pointed out the importance of an adequate time allotment for General Science and the need for all pupils to have an appreciation of the social significance of science, whether they are to be science specialists or not.

1845—The North-West Passage

A CENTURY ago Sir John Franklin embarked on his last voyage during which he discovered the North-West Passage. The voyage ended with his death in June 1847, from scurvy and starvation.

While in his middle 'teens, he had assisted in the survey of the long and then unknown coast of Australia and displayed great skill in astronomical and nautical matters. When his cousin, Captain Flinders, set up a small observatory at Sydney he employed "young John" as his assistant. Franklin, when only nineteen, was in charge of the signals at Trafalgar. From 1819 to 1822 he explored Northern Canada from the Great Slave Lake to the estuary of the Coppermine and then eastwards for 175 miles to Cape Turnagain. In 1823 he completed and had published a book, about that expedition entitled *Narrative of a Journey to the Shores of the Polar Sea*. On his return he was promoted post-captain and elected a Fellow of the Royal Society.

In his second overland Arctic expedition (1825—1827) Franklin descended the Mackenzie to its mouth and then surveyed the coast westwards to Return Reef, 160 miles from Point Barrow in Alaska. A colleague, John Richardson, closely studied the coast between the estuaries of the Mackenzie and Coppermine. These explorations were described in his second book, published in 1828. On April 29th, 1826, the Geographical Society of Paris awarded Franklin its coverted gold medal, for his contributions to geographical science; the British Government knighted him that year, and the university of Oxford conferred on him an honorary doctrate.

Whilst governor of Van Diemens Land (Tasmania) for the period 1836—1843 Franklin founded a local scientific society, which is now known as the Royal Society of Hobart Town.

Technological Training for Indian Students

THE arrival of Indian science students in Britain in the near future is to be anticipated since it is announced that the Government of India is making arrangements to send abroad 500 students for training in technical subjects directly related to India's various plans for post-war development. Preference will be given to graduates. Free return passage and reasonable expenses will be provided for selected students, some of whom will be selected directly by the Central Government, while others will be chosen in the first instance by Provincial Governments. Subjects covered by this scheme include agriculture, all branches of engineering (mechanical, electrical, civil, chemical, aeronautical and marine), architecture, applied chemistry (including food preservation), applied physics, geology and metallurgy. Separate arrangements are also being made to send students abroad for courses in medical subjects.

Houses Open at Kew

THE glasshouses and museums of the Royal Botanic Gardens, Kew, are now open. They had been closed ever since the beginning of the flying bomb attacks on London in June last year.

Control Commission for Germany

MR. J. R. MENZIES-WILSON has been appointed head of the metallurgical branch of the British section of the Allied Control Commission in Germany. The branch dealing with chemical controls is Mr. C. S. Robinson, Director-General of Ministry of Supply Filling Factories.

Fly Bombs Damaged London Zoo

THE extent of damage done by flying bombs to the London Zoo is revealed in this year's annual report of the Zoological Society. One bomb fell in the garden, and eighteen others near them, of which twelve damaged buildings in the grounds. The owls' aviary, the pheasantries and the hippotamus house will have to be rebuilt. The raids considerably reduced the number of visitors which fell from over a million in 1943 to a mere 266,658 in 1944.

Peak Year for Chemical Engineers

WITH the approval of the University Court, the Imperial College of Science and Technology has accepted a benefaction from Courtaulds, Ltd., which will yield an annual income of £3000. This endowment, and the money which Shell has made available to Cambridge University (DISCOVERY, March 1945, p. 95) were referred to at the annual meeting of the Institution of Chemical Engineers. One speaker described these endownments as "whetting the appetite of the chemical engineering profession", and another spoke of 1945 seeing chemical engineering in Great Britain take a great step forward.

Conference on X-ray Analysis

THE X-ray Analysis Group of the Institute of Physics held its annual conference in London last month. Sir Lawrence Bragg was re-elected chairman, and Mr. F. A. Bannister, of the Minerals Department, British Museum, was elected hon. secretary of the Group. Of particular interest was Professor J. D. Bernal's talk on "The Future of X-ray Analysis." He foresaw great developments in automatic and semi-automatic apparatus to cut down the labour of crystallographic analysis, and that applications of X-ray analysis would overshadow interest in it for its own sake. He predicted that X-ray diffraction outfits would become obligatory in all industrial, biological and chemical laboratories of any size.

Night Sky in June

M. DAVIDSON, D.Sc., F.R.A.S.

The Moon.—New moon occurs on June 10d. 04h. 26m. U.T. and full moon on June 25d. 15h. 08m. The following conjunctions take place:

June			
6d. 12h.	Mars in conjunction with the moon	Mars	4° N.
6d. 21h.	Venus ,,	Venus	3 N.
11d. 18h.	Saturn ,,	Saturn	0.6 S.
16d. 21h.	Jupiter ,,	Jupiter	4 S.

In addition to these conjunctions with the moon, Mercury is in conjunction with Saturn on June 24d. 11h., Mercury being 2.2° N. Saturn is also occulted by the moon on June 11d. 18h. 38m., reappearing at 19h. 29.8m.

The Planets.—Mercury rises about 20 minutes before the sun on June 1 and is in superior conjunction on June 16. At the end of the month the planet sets nearly an hour after the sun. Venus rises at 2h. 22m. on June 1 and 1h. 30m. on June 30, and is a conspicuous object in the eastern sky. The planet attains its greatest westerly elongation on June 24. Jupiter sets about 1h., midnight, and 23h. at the beginning, middle, and end of the month respectively. Its distance from the earth varies from 485 to 527 million miles between June 1 and 30. Saturn is becoming difficult to observe and in the middle of the month the planet sets a little more than an hour after sunset.

Times of rising and setting of the sun and moon are given below, the latitude of Greenwich being assumed:

June	Sunrise	Sunset
1	3h. 48m.	20h. 07m.
15	3h. 42m.	20h. 18m.
30	3h. 46m.	20h. 21m.

June	Moonrise	Moonset
1	0h. 02m.	8h. 38m.
15	9h. 16m.	———
30	23h. 32m.	9h. 00m.

There will be a partial eclipse of the moon on June 25, invisible at Greenwich, but visible over various parts of the southern hemisphere.

Summer solstice is on June 21d. 19h. On this date the sun reaches its greatest northern declination and almost stands still, so far as declination is concerned, for a few days, hence the name, which means the standing still of the sun. On June 20d. the declination of the sun is 23° 26′ 05.7″ and on June 23 it is 23° 26′ 26.8″, the greatest declination on June 21d. 19h. being 23° 26′ 47″. These figures show that there is some justification of the title "solstice" at this time of the year.

The long days combined with double summer time are not suitable for observing interesting objects in the heavens, and astronomers find the summer months inconvenient for observational work.

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